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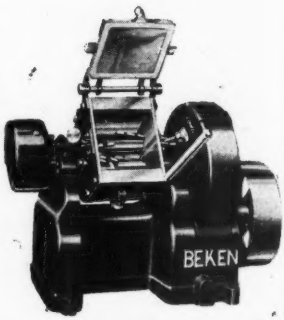

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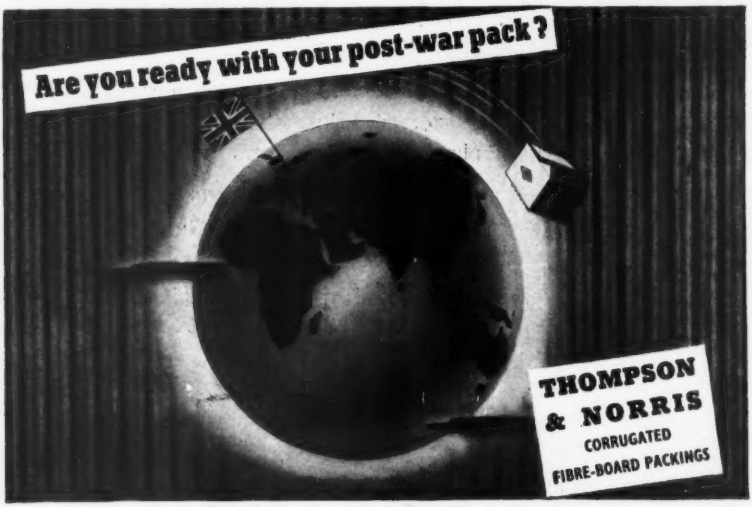

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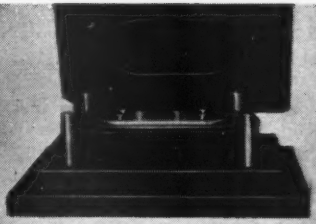

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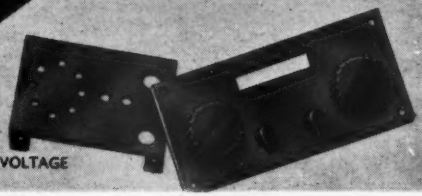

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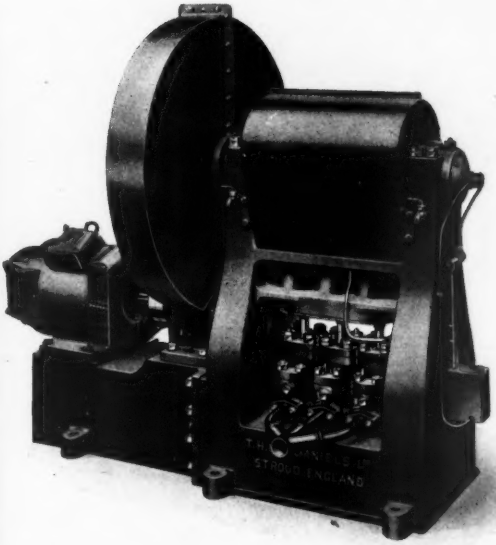

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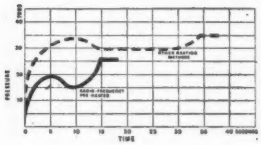

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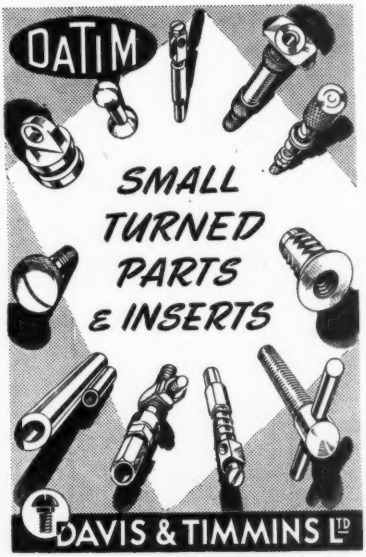

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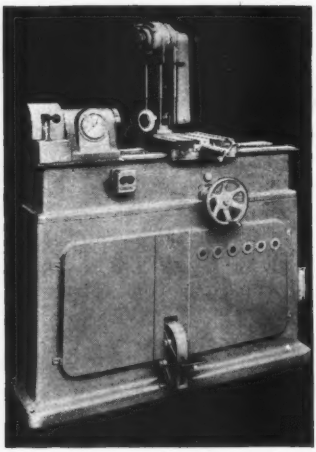

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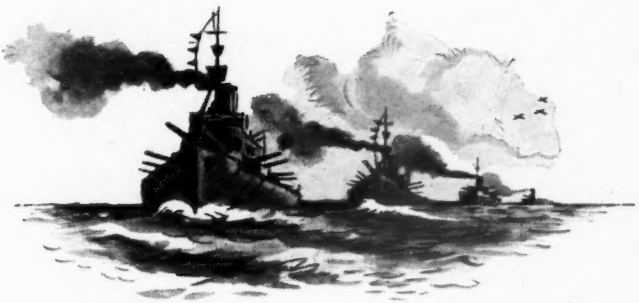

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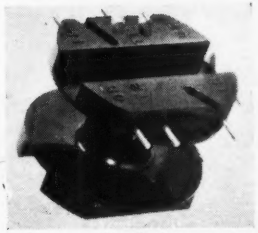
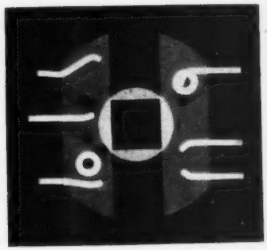


Photograph of moulded component—by courtesy of British Industrial Plastics Ltd.



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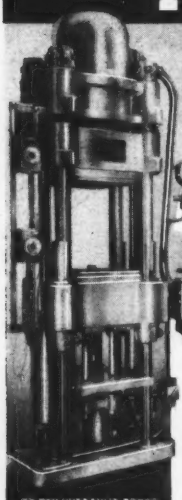

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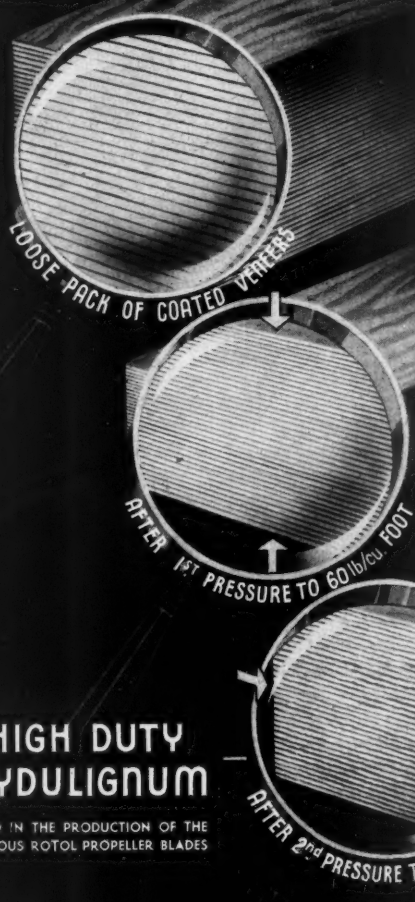

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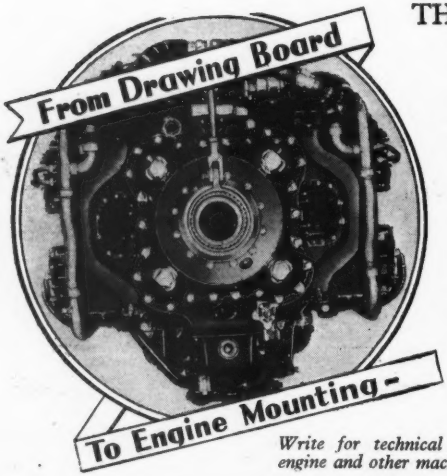

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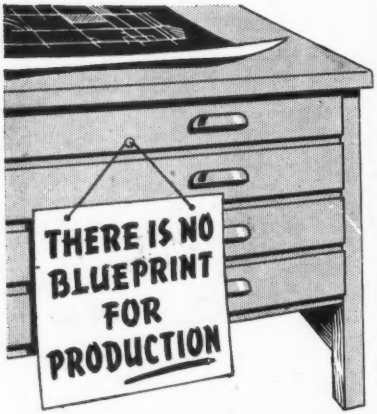

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"Oilite" reduces bearing failures to a minimum wherever it is applied to suitable components. The lubricant content is ample to cope with variations in speed and load over a considerable range, and will do this continuously during the life of the component, whilst, where necessary, additional lubrication can be readily embodied in the design without difficulty. The accuracy of finished dimensions and limits is equal to that of the highest grade machined bearings, thus making for ease of assembly and fitting. As an alternative to force fitting, "Oilite" Bearings can be incorporated in Plastic Moulding during Moulding, but will require impregnating with Oil after processing.

THE MANGANESE BRONZE & BRASS CO. LTD
HANDFORD WORKS, IPSWICH TELEPHONE IPSWICH 2127 TELEGRAMS BRONZE IPSWICH

NOW LISTEN YOU FELLOWS—
what do you want from the plastic moulding people?
surely it is—

ADVICE upon which you can rely as to the type of Plastic best suited to the specification of your job.

CO-OPERATION in the initial designing in order to make the job a sound moulding proposition.

CONFIDENCE that they will suggest the most economical and time-saving method of production and, above all, give you good mouldings and good deliveries.

THEREFORE GENTLEMEN YOU SHOULD CONSULT

CRYSTALATE

TONBRIDGE, KENT. HADLOW 233/4/5

MOULDERS IN PLASTICS SINCE 1899

Don't

UNDERWORK

YOUR OFFICE MACHINES

!

The output of work from typewriters, billing machines, book-keeping machines, teleprinters, tabulating machines and all other kinds of Form-Writing machines is to a very large extent governed by the type of stationery used in them.

Modern machines demand modern stationery —loose business forms and carbons cost far too much time in assembling and subsequent separation. They represent the stage of progress which succeeded the pen and ink method.

Business forms, like business machines, have gone several stages further. The modern office machine deserves to be fed with LAMSON PARAGON SPEED STATIONERY, the forms which keep office machines working continuously.

An example—a Lamson Paragon system—"PARABAR," in which by means of a single attachment, the great advantages of Continuous Forms can be obtained from almost any standard typewriter, without in any way interfering with its use for other purposes, such as correspondence.

LAMSON PARAGON

PLANNERS AND PRINTERS OF BUSINESS FORMS AND BOOKS

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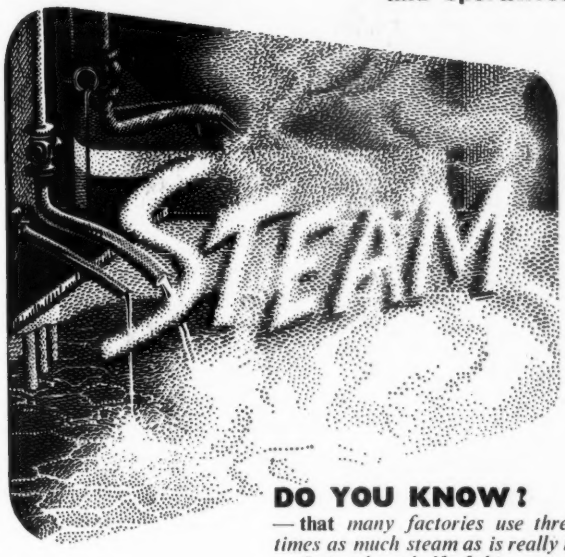
TAS/LP.46

A NEW FILM for Works Managements and Operatives



DO YOU KNOW?

— **that** *many factories use three or four times as much steam as is really necessary.*
— **that** *at least half of this waste can easily be prevented.*

The attention of all business principals is earnestly called to the 20-minute speaking film — " Steam " just released by the Ministry of Fuel & Power. It shows with pictures, diagrams and figures, the principal causes of steam waste, how this waste can be avoided; the best ways to insulate; the use of trapping systems; means of using low-pressure steam for process work; how to air vent steam heating apparatus; how to recover heat in condensate and flash steam.

ARRANGE FOR YOUR STAFF TO SEE IT — NOW Write to the Secretary of the Regional Fuel Efficiency Committee to find out what arrangements are being made in your Region.

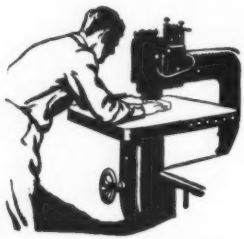
If a Ministry of Information van is visiting your works with other films, ask for the film " Steam " to be shown. (Also — if there's time — the accompanying film " Boiler House Practice ".)

If you have your own projector (16 mm. or 35 mm.) both " Steam " and " Boiler House Practice " will be lent without charge on application to the Secretary of your Regional Fuel Efficiency Committee.

Or combine with other firms for a joint showing. Nobody who uses steam for any purpose should miss it.

ISSUED BY THE MINISTRY OF FUEL AND POWER

Hints on machining
TUFNOL
THE ENGINEERS MATERIAL, NON-METALLIC. LIGHTWEIGHT



Fuller details of speeds and cuts are given in our "Manual on Machining Tufnol".

ROUTING. Use the routing machine for quantity production of shaped Tufnol parts. Make jigs in Tufnol, wood or metal. Tufnol is lightest to handle. Use single fluted cutters for Tufnol parts up to ½" thick, double fluted cutters for greater thicknesses. Rough profiling by band or fret saw reduces wear on cutters. Internal routing and deep profiling should be done in stages.

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137

KING *Electric* CHAIN PULLEY **BLOCK**

The King Electric Chain Pulley Blocks are built for continuous heavy duty. Three models are available: Minor, Major and Mammoth, ranging in capacity from 5 cwts. to 10 tons. Write for illustrated booklet on Lifting and Shifting.

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LIMITED
CELLULOSE ACETATE MOULDING POWDERS SHEETING, FILM AND TUBING

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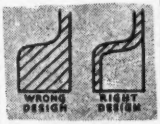
SMUGGLING IN INDUSTRY

In 1873 the Marquis of Salisbury, wishing to establish a new industry in India, planned to obtain rubber seeds from Brazil. It is said that 70,000 seeds were smuggled out of that country, with which were started plantations that have been yielding 1,000,000 tons of rubber yearly.

THIS IS EBONITE

Contrary to the general idea, Ebonite can be made flexible and elastic. It is one of the most useful of industrial materials. Hand-made articles, metal coverings and linings, composite mouldings incorporating soft rubber portions—these are sufficient to indicate the versatility of ebonite.



HINTS FOR THE DESIGNER

Plastic components are light in weight. They can be kept light by using a hollow form instead of a solid section. This saves material and avoids manufacturing difficulties. Unequal sections cause strains to be set up in the component. These may lead to distortion.

UEL

Present

PLASTICS

News Reel

No. 3

DESIGN

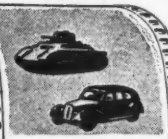
The manufacture of plastics is a mass production business but is nevertheless a craft. The skill of the craftsman who once patiently shaped and carved and polished each product of his hands has been replaced by the skill of the tool-designer and the toolmaker, creating the beauty, accuracy and finish of modern plastics.

That is why our service ★ employs the best designers and toolmakers to interpret our customers' ideas. Their work ensures that we can produce large quantities of rubber and plastic mouldings accurately, economically and with speed. Well-designed and well-made tools are initially expensive. They are the cheapest in the end.

★*Manufacture of Products in Plastics, Rubber and Synthetic Rubbers.*

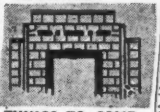
LORIVAL PLASTICS

UNITED EBONITE & LORIVAL LTD
LITTLE LEVER - NEAR BOLTON
Telephone: Farnworth 676 (4 lines)
Telegrams: 'Ebonite' Little Lever



FROM WAR TO PEACE

Certain plastic components have been made for fitting near the engines of tanks. They are made of a specially heat-resisting material with an asbestos filler to meet severe heat conditions. This material will be available soon for ash trays, gas or electric oven fittings, as well as for engine components of peacetime vehicles.



THINGS TO COME

The heat-resisting qualities of plastics, their wide range of shades, their high finish and the excellence of design to which they lend themselves, would seem to indicate that more handsome fireplaces will soon be a feature of the home.

NOW EVERYTHING IN THE GARDEN IS LOVELY

Fifty years ago rubber tubes—your garden hose for instance—were made by hand-winding strips of rubber; nowadays, extruding machines give a seamless tube of rubber or plastics, which is not only less liable to leak but also can be produced at a fraction of the cost.

Other advantages—Low Bulk Factor . . . . . Free-flowing . . . . . Easy of extraction and fast in cure—properties unusual with this type of material . . . . . Supplied in black and natural; can also be used for transfer moulding.

Full details with samples on request.

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Dominion and Foreign Representatives: A. S. HARRISON & CO. PTY. LTD., 85, Clarence Street, Sydney, Australia. JOSE DELCLOS, Gignas, 39 Barcelona, Spain.
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Vol. IX. No. 96 MAY, 1945

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.R.I.C.
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NOTICES

"PLASTICS" is published in London, England, on the second Wednesday of the month.

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Telephone } *Kenilworth* 415
Telegrams }

Northern Offices—Manchester: Deansgate House, 274, Deansgate.
Telephone—Blackfriars 5038-9.
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SAVE PAPER

More than ever is paper waste required for our war industries. Waste paper makes munitions in a hundred forms—from shell cases to aeroplane parts.

The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

EDITORIALS

The British Plastics Federation

WE recently commented on the fact that it had taken a war to unify the plastics industry, so far as a competitive industry can be unified, and that with the aid of the Federation (which now has 258 members), Plastics Control and its Advisory Section, we have now in being an industrial group which the rest of the world regards as a powerful factor in our post-war life.

At the recent annual lunch of the Federation at the Savoy Hotel (one guest pointed out that even the venue showed the upward path the industry was taking), we saw the full stature it has attained. The guests included Mr. Ernest Bevin, the Minister of Labour, Sir Bruce Gardner, members of the Plastic Control and many other Government representatives.

The Chairman, Mr. Graesser Thomas, opened the proceedings with a speech which, for flights of imagery and metaphor, has certainly never been equalled by his predecessors.

He spoke of what the industry had done in the war years and, in regard to exports, which we are asked to increase by 50 per cent., how eagerly we are awaiting a Government lead in this matter, otherwise we shall certainly be badly placed in comparison with America, which has recently become so export-minded, giving every indication that it intends to go for those export markets which for so many years have been within the British sphere of influence.

He also hoped that the Government would be helpful in re-equipping industry not only with regard to labour, but also technicians and new plant. We were pleased to hear from Mr. Graesser Thomas that through the medium of the groups the Federation is now working out schemes for the collection of statistics of the industry, so that, in addition to providing information for the benefit of members, it will be able to give much-needed information to Government departments, as and when it may be required, for the good of the Nation and the industry.

The groups and their management committees, the sections and the representative technical committees have met regularly and accomplished much good work, and also a number of other important committees have been set up by council, or by groups at the request of council, to deal with many important matters, such as the control of plastics materials in the post-war period. No fewer than 50 committees are now in active session.

Progress in the hall-mark scheme was also noted. The hall-marks of the Goldsmiths' and Silversmiths' companies, he said, are too well known and honoured throughout the world to need comment, and although the plastics industry was comparatively very young, it has thought it right to seek means whereby it can give a similar guarantee to the consumer, although, obviously, to accomplish this is a complicated task. With the assistance of the British Standards Institution, which acts as the independent adjudicator, licences have been granted to a number of powder manufacturers who may apply a mark, registered by the Institution with the Board of Trade, to certain moulding powders, which are therefore guaranteed to comply with the high standards set in the relevant British Standard specification. How this mark can best be applied to the finished article purchased by the ultimate user is also now being considered.

The plastics industry is the most youthful of all. Its life is being conducted with the vigour of youth, but with a wisdom older ones might well envy.

Control Will Continue

MR. ERNEST BEVIN, the star guest at the lunch, made as masterly a speech as we have ever heard. In simplicity of purpose and in simplicity and directness of exposition, the keys of mutual understanding, it was clearly one of his best.

He spoke about control and the absolute necessity to continue it for the time being. The policy of the Government, he said, is to make controls in a rational and orderly way for post-war industry. He made it clear that he did not want to use any kind of control developed in the war to secure any particular aim.

" You cannot, directly or indirectly," he said, " ask for man-power control after the war unless the capitalist side is under an element of control as well, in order that the two should run on parallel lines. You must have a sense of justice in this matter.

" The only way to do that is to inculcate in both the ex-soldier and the men and women coming out of munitions that everybody is trying to save the day in the interests of the country as a whole.

" Is ' get rich quick ' to be the motive or is order and discipline, which have carried us through the war, to be the motive?

" Can there be the same national discipline for enough years to help us regain a proper position as leaders of the world as well as restore our industries?

" If I had listened to some people there would have been chaos when D-Day arrived.

" I appeal to industry, which otherwise will descend into chaos, to stand up for those who want to put our industries on a proper footing.

" If I wanted to be popular I could go to the House of Commons to-morrow and say: ' All these controls have gone.' But I would rather go out of office for many years to come than sacrifice this nation.

" The country is at the parting of the ways. If industry and the trade unions work together during the vital transition, then I have no fear that Britain will not only get out of this terrible struggle, but will assure its future for a hundred years."

The Moulders' Grouse

PERHAPS it has been the loose talk of relief from control that is psychologically at the bottom of some recent discontent on the part of moulders. Most of us dearly hope for an end to it, and many of the rumours put about regarding impending release of this and that followed by subsequent denial or disappointment all help to fray our nerves.

We mention the following cases, not to apportion blame, for recrimination seldom benefits anybody, but merely to record them and to attempt a clarification, if that be not impertinent.

A short time ago Authority was prepared to grant licences and release urea resins for certain fancy goods; the spate of orders from buyers to moulders, and from moulders to resin makers that followed can well be imagined. In fact, the urea-resin cupboard was comparatively bare and the grouse is that somebody should have first ascertained the nakedness of the land before thinking about granting licences and overwhelming the moulders with futile work and worry.

On close examination, the trouble proved to be that while sufficient urea-formaldehyde resins could easily have been made to meet all demands, much of the labour was suddenly and contemporaneously drawn away to meet another and much more important demand of high priority material. At the risk of getting our throats slit—there is still a war on, and another beyond the European one.

It is quite clear that the bottlenecks created by shortage of material had become less serious. The labour shortage, on the other hand, has gone from bad to worse, that is in the southern half of England, and if stones are to be slung it is in the direction of the Ministry of Labour and its satellites. To us it is clearly a case of unavoidable hard luck all round but that many moulders were not told the whole story, which is a pity.

The second case, however, is certainly

one of raw material, and the story is more than normally interesting. There is an impression that cellulose acetate has been in plentiful supply since some quantities have been used for quite a number of un-war-like objects but are nevertheless essential to the housewife. In the last year the situation has, in fact, been poor, because of the almost complete withdrawal of the phthalate esters used as plasticizers, and what acetate is available must be used for the higher categories of priority. The raw material, phthalic anhydride which is made from naphthalene has been transformed into dimethyl phthalate for use as mosquito and midge spray for the armies in the East. Some quantity of phthalic anhydride is also converted into fluorescein which is carried by all aircraft crossing the seas, for when thrown into water it covers a very wide area with a bright yellow colour and so facilitates rescue work. Hence no phthalate plasticizers for acetate.

Some relief appears to be on the way, for news comes that a big factory for producing phthalic anhydride is in course of erection in the U.S.A., where there is plenty of labour.

Perhaps, in view of the fact that demands for phthalic anhydride will increase with new outlets, somebody will put up a little factory in the North where labour is much freer.

Import Duties on Oil

THE Chancellor of the Exchequer improves steadily in his attempt to understand the aims of the scientifically controlled industries, including especially the chemical and plastics industries.

While he does not appear terribly sure of the value of his "gifts" in the following abstract of his speech, most of us believe that they are good investments, which will be repaid many fold.

"In my Budget speech last year I referred to the intention of my right hon. friend the Minister of Fuel and Power and myself to appoint a committee to study certain questions of great industrial significance in connection with the duties on hydro-carbon oils. The committee which we set up was presided over by Sir Amos Ayre, and hon. members will find a full disquisition upon this important and intricate subject in the committee's most able and useful report which was published as a White Paper on April 11. I propose to accept the recommendations of the committee. The Finance Bill will include a provision freeing from Customs duty imported hydro-carbon oils used as raw materials for chemical synthesis. Provisions will also be made for an allowance of an equal amount to the Customs duty in respect of indigenous oils used in these processes in order that the competitive position in respect of home-produced materials shall not be worsened by this change.

"There are many who believe, notably in the United States, that the synthetic chemical processes based on the use of hydro-carbon oil are going to be of rapidly growing industrial importance and will affect the manufacturing methods of many industries which lie outside the field of synthetic chemistry. Research on these problems has been active in several countries during the past five years. I hope, therefore, that the double gift I have found myself able to make towards the cost of research in my last Budget and now in respect of the raw materials of this important new industry will lead to an intensifying of co-operative effort so that we can quickly establish ourselves in a worthy position in relation to these new developments."

PLASTIC MILK BOTTLES

Last month there appeared in a well-known daily paper a description of a plastic milk bottle, with the inference that such bottles were now or are shortly to be available. A price was given.

Many inquiries were received at this office and the "producing" company were inundated with orders.

Since the plastic milk bottle in question, in view of limitations of raw material supply, plant and labour, is quite impossible of manufacture during war-time, it is more than a pity that such premature publication was made.

THE BRITISH TECHNICAL PRESS

In our April issue we sketched out some of the difficulties that face the technical Press of this country vis-à-vis the productions of more fortunate countries in wartime.

A much fuller explanation has now been published in pamphlet form by the Council of the Trade and Technical Press; it is also not "an apology for its existence," but a strong plea to the industrial world and to the Government to understand clearly the true function of this section of the Press as a vital element in the growth of any industrial country.

" Show us your technical journals and we will tell you what place you hold in the modern world," may yet be regarded as no untruthful aphorism.

The pamphlet shows how this Press with its delineation of scientific progress and improvements in design, materials and production methods, so covers fields of information essential to manufacturers that it has become as important to the conduct of his business as are the very tools he installs.

The journals will be of outstanding value in the change from war to peace from conditions which have forced some manufacturers to a makeshift compromise between what is best and what is available. The need will apply in particular to manufacturers who, during war-time, have departed from their normal activities and now find themselves equipped for production foreign to their pre-war activities. The technical Press must and can reduce this gap.

Important as must be the part played by technical journals in the re-establishment of industry in this country, their part in the fight for export trade will be of equal if not of greater importance.

To the reader abroad engaged in the industry with which any given journal deals, such a journal mirrors the whole progress in this country of scientific research and developments in production methods. By such a journal the potential buyer judges whether Great Britain is the best market to satisfy his requirements. Quality of production and presentation was and will be again of primary importance to technical journals as the overseas reader tends in the first instance to judge the quality of the goods by the quality of the journal in which they are described.

Given the necessary facilities, now unhappily lacking, publishers of British technical journals are ready, able and eager to produce publications which in content and appearance would certainly compare favourably with those of any country in the world.

After nearly four years of extraordinary difficulties, during which it has carried on its work with a basic ration of approximately one-fifth of pre-war consumption the technical and trade Press require from the Government:—

(1) Additional paper of a quality which will stand comparison with that used, for example, by competitive journals abroad. The actual quantity is not great.

The additional paper is needed so that both editorial contents and manufacturers' announcements can be greatly extended, advertisement pages in a technical or trade journal being an integral part of the whole essential to the reader.

It is further needed, since at present publishers are unable to meet the demands of any new readers.

(2) The early release of a small number of skilled operatives for the manufacture of high-grade paper, for printing, and in particular for block-making which constitutes a serious bottleneck. Quality and quantity of illustration and free availability of colour where desired are essential to creating a favourable first impression, particularly abroad.

(3) The early release of experienced technical and trade key men to supplement editorial staffs.

(4) A high priority for the provision of new and up-to-date printing machinery. Labour and material involved are relatively small.

(5) The release of full information on the many new discoveries and inventions that British scientific research has evolved and British technical skill developed during the war.

A policy of extreme caution on the part of Government departments has on occasion resulted in the release of information abroad ahead of its release in this country. As a result credit for scientific development and inventive genius has not always been given where it belonged.

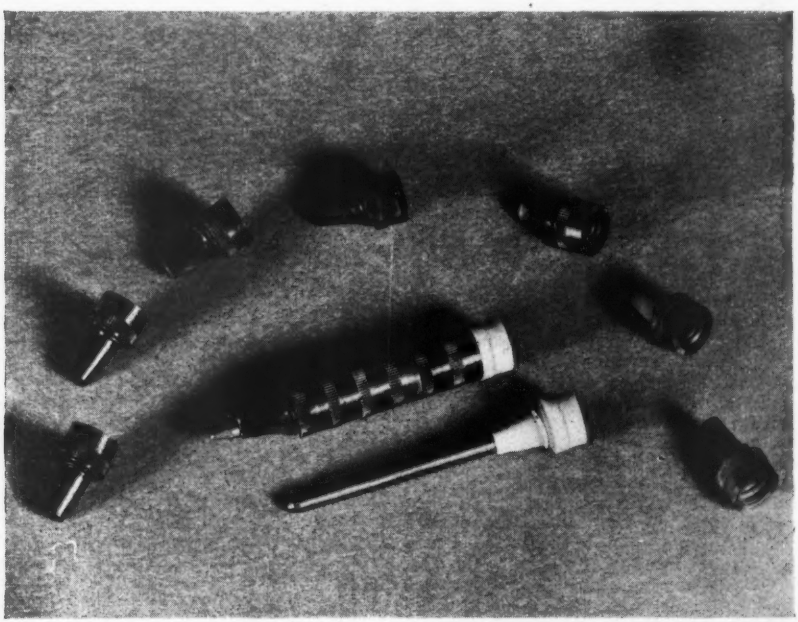
(6) The close collaboration with the Government at home and its commercial representatives abroad which has long existed in other countries, in particular the U.S.A. and Germany. No consultation with industries should take place without representatives of the technical and trade Press, who are in the best position to review any industry dispassionately as a whole.

Hold Your Lead in Pencils

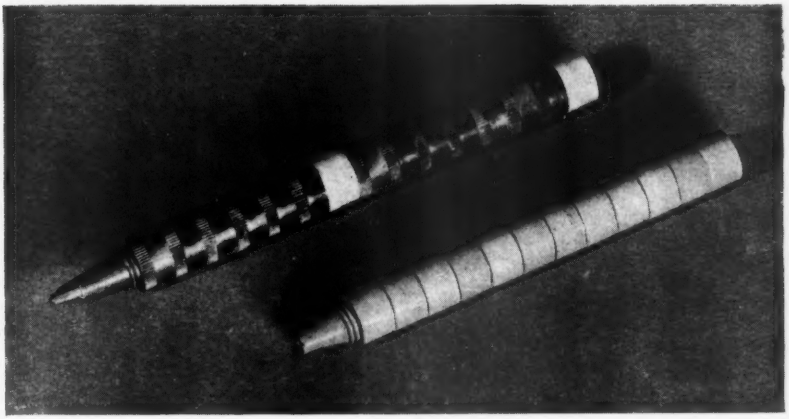
FOLLOWING the career of an idea, even if it is not world shaking, is one of the most fascinating games we know—provided, of course, that its progress is brightened with some success. So many fail after birth, from reasons varying from bad parentage to lack of A-Z vitamins, that the path from the clinic (in common parlance, the Patent Office) is not only strewn with good intentions, but also with many minor tragedies. Now and again, happily, the birth is fortuitous and the child grows to a lusty infant, reaches the world and is accepted as a healthy youth, to the great joy and, we hope, profit of its parents.

One such has been brought to our notice, and in a very pleasant way, as the following letter shows:—

Dear Sir,—Several years ago you were good enough to give us some badly needed encouragement in the development of our Moulded Plastic Pencil, honouring us, in fact, by the inclusion of a description of the



Breakdown of pencil, showing individual mouldings and the two special "lead-" holding units.



Comparison between the original experimental model and the production type.

pencil in your article " Ideas " of the October, 1939, edition of your journal.

We thought it therefore fitting that, having now reached production stage with sales in their tens of thousands, you should be the recipient of a sample model, confirming your early confidence in its future.—Yours faithfully,

THE JEFFREYS PENCIL CO.
(H. W. J. Jeffreys).

The pencil in question was enclosed and is reproduced at the head of this article.

Then we remembered the days before the war when we received an early experimental example of the pencil. The main idea has not been altered fundamentally, consisting of the use of a number of externally and internally threaded units, each of which is removed from the top and inserted into the end, as the " lead " is used up, thus exposing a fresh piece.

The pencil actually contains two separate leads each fitted into two special units, shown in the photograph as lighter coloured than the normal moulded unit. There is also a difference between the moulding of these two and that of the other darker-coloured mouldings, in that the former, since they hold the " lead," are provided with a fine adjustment so that the " lead " neither slips through nor is it too tightly held. The central tubular passage in the remaining units is, however, concentric, allowing the lead to slip through easily. Another difference between the original sample, which was moulded by Mr. Jeffreys himself, and the new one is that all units are provided with knurls to facilitate unscrewing.

The moulding is carried out by the injection process in cellulose acetate, by Punfield and Barstow, Ltd., Westmoreland Road, Queensbury, London, N.W.9. The sole distribution is handled by Bailey's Agencies, Ltd., Farringdon Road, London.

WILLIAM COWEN, M.Sc., A.M.I.Chem.E.—We regret to announce the death of Mr. Cowen, who was a member of the staff of Lansil. Ltd., the acetate manufacturers of Lancaster. Prior to joining this company he was lecturer in industrial chemistry in the faculty of chemical engineering at the University of Manchester.

JOS. PROKOP AND CO., 3, South Place, London, E.C.2, write in to the effect that this company is the sole supplier of Kamite stone and not F. and M. Suppliers, Ltd., as stated on p. 174 of the April issue.

E

Plastics in Tool, Jig and Fixture Construction (Contd.)

By E. E. HALLS

IT is to be noted that there are a number of manufacturers established in the art of making these synthetic resin laminated materials of fabric and paper base. Each can produce a range of grades within any of the specification limits discussed, with the distinction between the grades characterized by a tendency to something special in one particular direction. This may be machineability, hardness, mechanical strength, water absorption, or other specific property. With reputable suppliers, it will be found that, for any one particular grade, the properties maintain a close degree of constancy, so that a user can rest assured in repetition buying. For tool work, the quantity of material involved for any particular job is rarely large, and this uniformity of characteristics from batch to batch may be of great importance. From a fundamental understanding of the nature of the raw material, and by co-operation with the makers, the technique of selecting a number of standard grades is rapidly acquired, and the adoption as far as possible of standard sizes soon follows. Purchasing specifications can be compiled to cover the type of material desired, and which is found suitable, if necessary. The procedure suggested in these respects is, in fact, identical with that usually followed when dealing with the tool steels.

Attention is drawn to Fig. 66, an intricate machining job on Bakelite laminated is illustrated. The high grade raw material involved is supplied by Bakelite, Ltd., and the machining executed by J. Burns, Ltd. The complicated component produced is a gauge for measuring the internal accuracy of shell noses. This use of phenolic resin laminated for inspection gauges is not an isolated case; the material resists wear exceedingly well, and in many instances it shows better resistance to abrasion resistance, and greater dimensional stability than the metals when used under similar circumstances.

One of Herbert Chase's articles some years ago in the " Machinist " dealt with

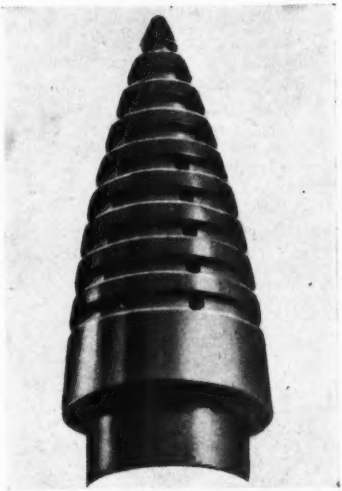


Fig. 66.—Bakelite gauge for shell noses machined from laminated material.
(Courtesy Bakelite Ltd.)

materials and processes at the Synthane Corporation's plant at Oaks, Pa., under the title of " Machining Laminated Plastics." Some of the information presented shows established uses for tools and the like. Consequently a few points abstracted from this article are of current interest.

The production of ball-bearing cages

can first be cited, although some may regard this item as part of a machine rather than as a tool component. However, the fact that plastic cages are used is of prime interest, and that they are made by turning operations on synthetic resin laminated, and the procedure adopted, are informative. For the purpose, fabric impregnated in phenolic resin varnish is the initial raw material employed. This is tightly rolled on a mandrel and then baked on this mandrel in order to cure the synthetic resin. The result is a light tube of homogeneous section, and one that is found to be well suited to the manufacture of ball-bearing cages. A short length of the tube is chucked in a lathe and, by this means, rings of the required length are parted-off with a straddle parting tool. For tubes of 1.75 in. outside diameter the speed of rotation is about 1,800 revs. per min. The rings are mounted, four together, on a mandrel slightly shorter than the combined length of the rings, and they are clamped endwise in order to prevent them from turning. The outside diameter is then turned, using a carbide-tipped tool with a feed of 0.004 in. per revolution, and the work rotating at 1,800 revs. per min.

For boring the insides, it is particularly to be noted that the chuck for holding the rings is itself made from "Synthane," a phenolic resin laminated material. The rings are separately mounted in the chuck, and turning speed is again about 1,800 revs. per min.

The radial holes are produced by drilling on light drill presses, the work being mounted on an arbor held in an indexing fixture. A drill guide bushing is in the fixture mounted just above the work. An alternative procedure uses a ring-shaped jig provided with a drill bushing for each hole. It is mounted so that the ring can be turned to bring the holes successively under the drill. The drills employed have the fast type of helical polished flutes, the points having an inclined angle of 90 degrees to 100 degrees, while the cutting edges possess a rake of 3 degrees. Drills having this form help to remove the chips quickly. Despite the heat generated, no coolant is employed and a tolerance on diameter of the hole of plus or minus 0.005 in. is maintained. Where deeper holes are required, it is found necessary to back the drill out occasionally in order to keep it cool.

Apart from closeness of dimensions, freedom from burrs is another essential on ball-bearing cages. Carborundum wheels, very small and spherical in shape and having a grain of 100 to 120, are used at high speed to remove burrs from around holes. When the design of the cage is such that it is split through a central plane, burrs are removed by buffing each half separately.

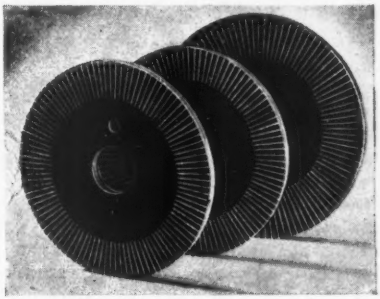


Fig. 67.—Screw-machine cams for controlling the tools are made from laminated sheet discs with radial marks at five-degree intervals. The cam is cut on a bandsaw.
(After "Machinist.")

The screw-machine cams shown in Fig. 67 are made from synthetic resin fabric laminated. Generally, they are cut from sheet, using a bandsaw. The latter usually has four teeth per inch, and it is set to cut a slot about $\frac{1}{16}$ in. wider than the thickness of the saw blade, the latter being 0.045 in. for 1¼ ins. in width and 0.035 in. for saws 1 in. in width. It is also to be noted that such pieces can be made by a combined procedure of laminating and moulding, a process used for odd shapes, sections, etc. The varnished fabric cut to shape is dried to free it from solvent and is placed in the mould. It is preheated to soften it, and then the mould

Fig. 68.—Synthane products are used as containers for pickling of metal parts. Holes are drilled in the tubing by the multispindle drill.

(After "Machinist.")

is closed slowly and finally cured under the full pressure. Gear blanks are produced in this way, or partly from the laminæ of impregnated fabric and partly from flakes of macerated fabric of the same type. Such a procedure exercises economy in material, because not only can the scrap fabric be used for producing the flakes by maceration, but also the loss encountered in cutting the discs from fully cured sheets is avoided. The method applies to parts in which a form or dish is embodied—at least, within the limit of the flexibility of the fabric employed.

Another extensive phase of the Synthane Corporation's activities concerns fixtures or the like for metal-finishing operations. The chemical inertness of the material permits of numerous useful applications in this direction. Fig. 68 shows the drilling of the perforations in a container for acid pickling of metal parts. The phenolic resin laminated tubes for this purpose are made with a wall thickness of 0.5 in., in diameters from 8 to 12 ins., and in lengths up to 36 ins. The drilling of the perforations is done on a Natco multiple-spindle drilling machine, with the tube mounted on a fixture, which can be traversed longitudinally and indexed to give the required angular spacing of the radial holes. Nine or more holes can be drilled at one time. The tube is closed by threading one end and fitting a screw cap and rings made from sheet stock of the same material. Containers of this type are very successful in chemical and electro-chemical finishing processes, in which they may be used in the form of baskets for handling work through mild alkali and dilute acid solutions, or as rotary barrels and baskets in electroplating equipments. They thus serve a purpose for which metal is unsuitable, earthenware is heavy and friable, and wood has too short a life, apart from being unsatisfactory in any case for many purposes. Quite long life is achieved using the high-grade plastic laminated materials of low water absorption characteristics. Nevertheless, there is an obvious limit to serviceability, this being chiefly set by gradual mechanical deterioration due to the heavy nature of the service, but it is also shortened by the alternating conditions of wet and dry, heat and cold, as well as deterioration from solvent and chemical action to some degree. These items are, therefore, of an expense nature in the category of jigs and fixtures rather than capital expenditure classed as plant.

The same material is serviceable in electroplating shops for the framework of jigs and fixtures for carrying the work through electroplating baths, thus minimizing the amount of metal, and therefore the quantity of current in excess over that required for electro-deposition proper.

The manufacture of high-purity chemicals, especially fine chemicals, medicinal and pharmaceutical products, involves special attention to materials of construction for plant and equipment, including dissolving vessels, reaction pans, filtration plant, etc. In some cases metals are permissible if they are inert towards the materials handled at all stages of processing. Aluminium, pure nickel and stainless steel are among such metals, but non-metals are essential in, perhaps, the majority of cases. Stoneware, glass, silica and plastics, such as keebush (a proprietary phenolic resin moulded type of

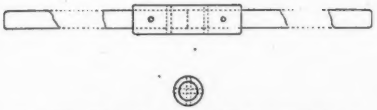


Fig. 69.—Phenolic resin rolled and moulded rod, two lengths butted and fixed by a tubing of similar grade.

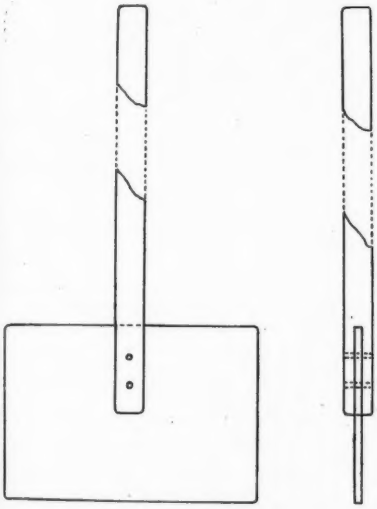


Fig. 70.—Paddle stirrer of phenolic resin paper laminated rod (rolled and moulded type) and phenolic resin fabric sheet.

material) and polyvinyl chloride, will be extensively used for plant, and, therefore, some tools and accessories should be of the same material. Earthenware, glass and silica equipment all tend to excessive fragility, and it is found that plastics lend themselves more readily for robust working and good qualities of wear and tear.

The high-grade synthetic resin bonded paper rod material is excellent for manually operated stirring rods. When longer rods are necessary than can be supplied in one length, two lengths can be joined together by utilizing a sleeve made from tubing of material of the same quality. The two pieces of rod can butt, and the sleeve can be fixed by dowelling. Again, if a vane or paddle attachment is required, then this can easily be provided by slotting the rod, and fixing the paddle by dowel pins of small-diameter laminated rod. The paddle itself would be made from high-grade phenolic resin paper and fabric sheet material. The method of sleeving is illustrated in Fig. 69, and the paddle attachment is shown in Fig. 70.

Plastic resin laminated is more robust than the glass and porcelain type of materials for spatulas, scoops, shovels and the like. The high-grade paper or fabric laminated products can be used. Rarely is the quantity involved sufficient to warrant moulding, although an impact resistant grade of phenolic resin moulded would be suitable. In fact, a few standard shapes and sizes in shock-resisting bakelite made available on the general market, and stocked by laboratory furnishers, for example, would be very welcome. More usually, it is necessary to make such items from sheet, tube, rod and section by building up. Flat spatulas and spade-like scoops can be made from sheet by shaping in the appropriate manner, rounding all edges, chamfering the leading edge, and milling the central portion as desired. This type of construction is illustrated in Fig. 71. A built-up type is shown in Fig. 72A. In this the body of the scoop can be made from channel section, or it can be produced from tube split in two parallel to the axis, as demonstrated by the construction shown in Fig. 72B. Assembly can be achieved by cementing with a bakelite cement, with reinforcement effected by dowelling. Cut edges can be radiused slightly, the leading edge can be chamfered or bevelled, and all cut edges finished perfectly smooth.

Various covers for plant units, boxes or containers for chemicals, wet or dry,

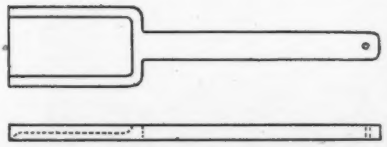


Fig. 71.—Flat scoop or spoon machined from phenolic resin laminated sheet.

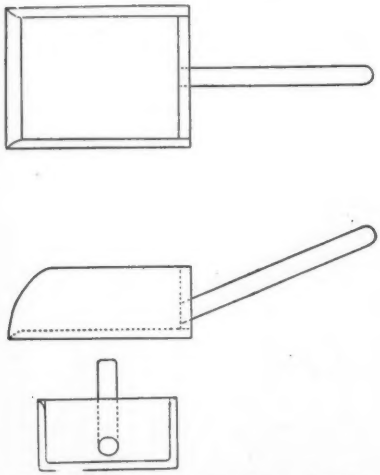


Fig. 72A.—Built-up scoop from phenolic resin laminated section, sheet and rod.

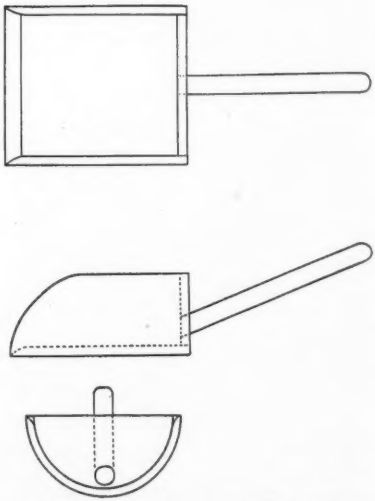


Fig. 72B.—Built-up scoop of phenolic resin laminated tube (split axially), sheet and rod.

in intermediate or final stages of processing, or as receivers from grinding or sieving operations, locating fixtures for measuring and filling devices, small hoppers and chutes; all these can effectively be fabricated from the materials within this group. Fig. 73A illustrates one form of all non-metal eccentric end-runner grinding mill, in which the deflector baffle can be provided in phenolic resin laminated, as shown in Fig. 73B.

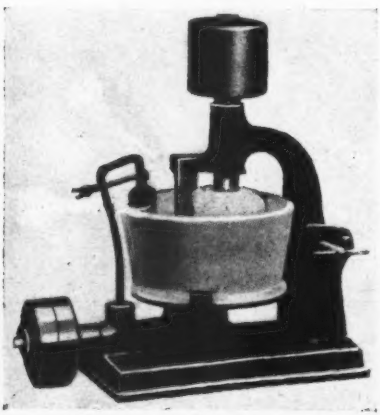
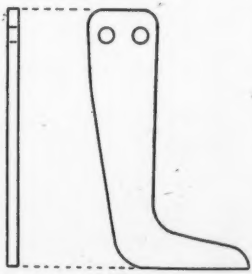


Fig. 73A (left). —Ceramic mill with deflector baffle and scraper made in phenolic laminated sheet (Fig. 73B on right).



Further, a dust cover when required can be made in the same material, and constructed in such a manner that it fixes to the stationary pestle and to just clear the rotating mortar. A cover of this type is shown diagrammatically in Fig. 73C.

In Fig. 74 is shown an all-plastic fabricated box with all inner junction edges reinforced with phenolic resin paper laminated material of triangular section. The latter can be sealed in and coated with bakelite varnish. Alternatively, dowelling and cementing the assembly is quite satisfactory. Again, for light work, screwing directly without corner reinforcements can be employed. In this case a

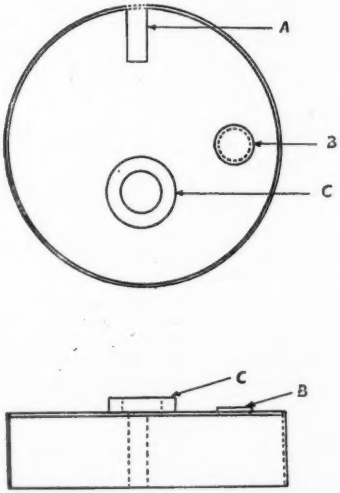


Fig. 73C.—Mill cover of rigid resin fabric sheet and flexible resin fabric surround. A, clearance slot for scraper; B, filling holes with swivel disc cover; C, metal fixing collar.

material thickness of ¼ in. minimum is necessary, and a high grade of fine-weave phenolic resin fabric laminated is preferred.

Fabricated boxes of this type give very good service. They do not distort, chip, dent or buckle, and no deterioration from corrosion, of course, is evident. The boxes remain neat and clean, and there is no difficulty in washing them with water or other appropriate solvent. For circulation around a cycle of operations with appreciable man-handling, they have proved quite serviceable for loads from 100 to 150 lb., and to have appreciably longer life than enamel-coated iron or steel, glass or earthenware containers.

In the light engineering industries numerous small assemblies are produced by soft soldering, using acid fluxes having hydrochloric acid, zinc chloride or "killed" spirit as the basis. Simple, rapid-operating fixtures are extensively employed. The low water absorption grades of phenolic resin paper laminated are admirable in many cases, because solder will not accidentally take upon them, they are easily washed free from flux without any fear of rusting or corrosion at the end of the soldering period, and, in operation, they do not conduct heat away rapidly from the work.

Again, much soldering is performed to-day on simply designed machines or fixtures, using electric power as the source of heat. Particularly where electrical insulation is additionally required, this class of material is suitable for fixtures or portions of fixtures, such as locating pieces and holding clamps. The same applies to spot and butt welding, and to resistance heating methods of joining in general.

Fig. 75 (after Plastics Catalog, 1941) shows plastic tools for removing electrical fuses. These tools are made by the National Vulcanised Fibre Co., of America, and they are produced by blanking phenolic resin laminated sheet, the blanks then being assembled by riveting. This is clearly shown in the illustration, and the blanking method enables maximum speed of production and economy to be achieved, as well as the assembly of a neat and efficient tool that

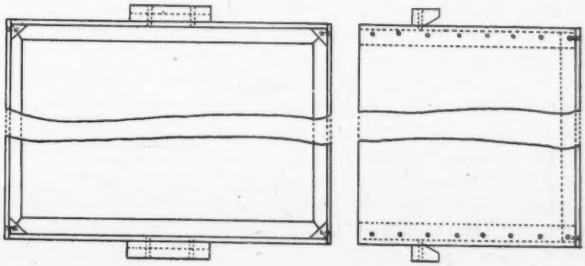


Fig. 74.—Construction of a box from phenolic resin laminated sheet.

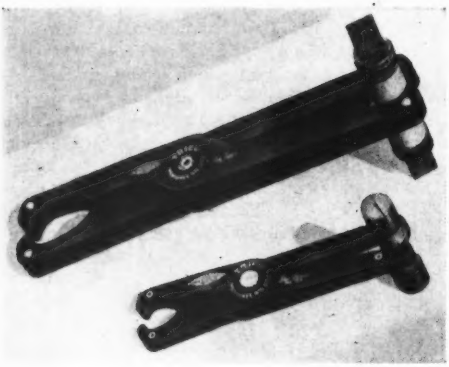


Fig. 75.—Tools for withdrawing fuses. They are blanked from laminated material and riveted.
(After "Plastics Catalog.")

is safe in use. In this country a very similar tool is made from phenolic resin laminated wood, and again this is an item that should be required in sufficient quantity to justify the standardization of a few sizes and their production by moulding in an impact resistant quality of phenolic resin moulding powder or thermoplastic such as diakon.

In the electrical industry, quite a number of screw-drivers, is used in which the blades are machined from phenolic resin laminated, usually rod of suitable diameter. This is because it is not always sufficient to have the handle composed of insulating material, it being necessary to have the blade electrically non-conducting in order to avoid the possibility of accidental short-circuiting between contacts, busbars, leads, etc. In high-frequency work, the blades may have to be of low-loss ceramic, and this may be cemented in handle of phenolic resin plastic material. Fig. 76 diagrammatically shows one of these H.F. screw-drivers. The ceramic blade A and tommy-bar C are designed for commercial limits with respect to dimensions. The remote end of the blade fits with easy clearance into the phenolic resin laminated paper tube B, the housing being drilled to receive it. It is firmly secured with a solventless thermosetting cement, for example, with a 50/50 mixture by weight of plaster of paris and bakelite cement, these two ingredients being uniformly incorporated by grinding together. In order to execute the joining neatly and efficiently, the central core of the laminated tube is fitted with a loosely fitting brass rod, the housing filled with the cement, and then the blade piece is forced home, ensuring that it is centrally positioned. The excess of the cement that oozes around the blade is cleaned off by scraping with a knife, and finished c l e a n by wiping with a cloth moistened with methylated spirit. The assembly is then placed in a simple fixture in order to maintain proper alignment, and to prevent the blade from pushing outwards, and it is baked. For the latter, from 24 to 48 hours at 60 degrees C., followed by 3 to 4 hours at 100 degrees to 120 degrees C. represents a suitable stoving cycle. The central brass rod is removed after about six hours of baking, otherwise it may become cemented in position. The preliminary low-temperature baking period is to expel volatiles gradually without causing any blistering and to avoid the formation of a porous conchoidal structure in the cement. The final high-temperature baking is to effect full curing of the resin, and to develop maximum adhesion and maximum torsional strength. The cemented junction will, in fact, withstand all wear and tear, and will outlast the blade.

When resistance to heat is specifically required to a greater degree than is

Fig. 76.—Screw-driver for H.F. electrical work. A, ceramic blade; B, phenolic resin paper laminated tube holder; C, ceramic handle.

Table 24.—Tolerance on Thickness of Phenolic Resin Laminated Asbestos Sheet.

Nominal thickness of sheet in inches.	Tolerance, plus and minus in inches
Up to and including $\frac{1}{16}$ ..	0.006
Above $\frac{1}{16}$ to $\frac{1}{8}$ inclusive ..	0.009
Above $\frac{1}{8}$ to $\frac{1}{4}$ inclusive ..	0.015
Above $\frac{1}{4}$ to $\frac{1}{2}$ inclusive ..	0.022
Above $\frac{1}{2}$	0.030

offered by the fabric and paper laminated materials already referred to, a material of similar construction, but having laminæ of asbestos cloth, is possible. This is available in sheet form, and there are a number of brands available closely similar to the phenolic resin fabric and paper sheets in quality. The material consists of superimposed layers of asbestos impregnated with phenolic resin varnish, dried, and the stack cured by heat and pressure to a compact, hard board. The material has low water content and low water absorption characteristics.

The intensity of heat that these phenolic resin laminated materials will withstand is dependent in some measure upon the manner in which this heat is transmitted to the material. This includes the directness or indirectness of the heat applied, the uniformity and rate of heating, as well as upon the quantity of heat. However, for general purposes, it can be said that the fabric and paper laminates deteriorate rapidly from blistering and swelling between 100 degrees and 150 degrees C., with 135 degrees C. as the normal average limiting safe-working temperature. On the other hand, the asbestos laminates similarly deteriorate between 150 degrees and 200 degrees C. with 170 degrees C. as the usual limiting safe-operating temperature. This is, therefore, the outstanding merit of the phenolic resin asbestos sheets.

The actual asbestos content of these materials is between 40 and 60 per cent. by weight, a feature that contributes favourably to rigidity under damp conditions or upon exposure to fluctuations in temperature and humidity. On the other hand, it can create difficulties with machining due to the greater wear upon the cutting edges of tools such as saws, milling cutters, drills, taps and punches. It is wise, therefore, to bear this point in mind and to select grades of phenolic resin asbestos laminated in which this shortcoming is not evident to any serious degree.

The asbestos laminates can be supplied in sheets of similar size to the fabric and paper base material, and down to surprisingly thin thicknesses, e.g., 1-64-in. Commercial tolerances upon thickness that can reasonably be expected are given in Table 24. Fig. 77 shows water absorption, and Fig. 78 moisture content, in terms of the maximum limiting curves

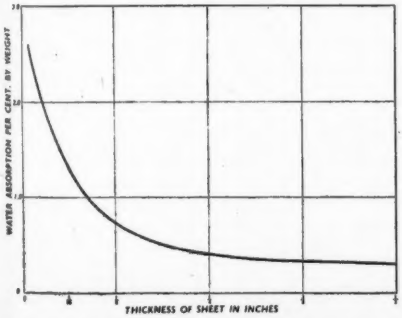


Fig. 77.—Maximum moisture absorption values for phenolic resin asbestos laminated sheet.

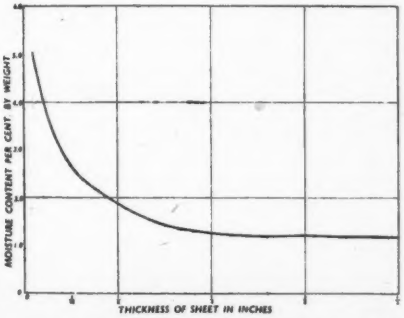


Fig. 78.—Maximum water content of phenolic resin asbestos laminated sheet.

that can comfortably be conformed to in practice.

The usual hot oil test and machining tests can be satisfied by the phenolic resin asbestos laminated material. Regarding mechanical strength, a minimum tensile strength of 10,000 to 11,000 lb. per sq. in. can be provided. Mechanical strength properties should not be appreciably deteriorated by virtue of exposure to dry heat at 150 degrees C. for a period of 24 hours.

In the lighter spheres of both general and electrical engineering industries, there are useful applications for these various sheet and rod forms of phenolic resin laminated, especially the fabric base types, for those jigs and fixtures that may be classed as transport trays and boxes. These are used for conveying fragile components, those likely to become burred or dented, those with accurately finished seating surfaces, or important screw threads, and the like. These fixtures are designed in a simple way to locate the components, and yet may be readily loaded and unloaded. Essentially, they may be merely pin trays, comprising a base board fitted with regularly spaced pins over which the articles are placed, or, again, the parts may be located in recesses or slots. A complete tray or box often comprises a standard-sized transport box, made of wood, containing loosely but well-fitting insets. These fixtures take the work through the various machining operations in the press and automatic machine shops, perhaps through heat-treatment rooms, and to cleaning, electroplating, enamelling, lacquering, or polishing, in accordance with requirements and the finish specified. Thereafter, the work may be specially packed or may go to store in the fixtures ready for passing to the assembly shops at a later date.

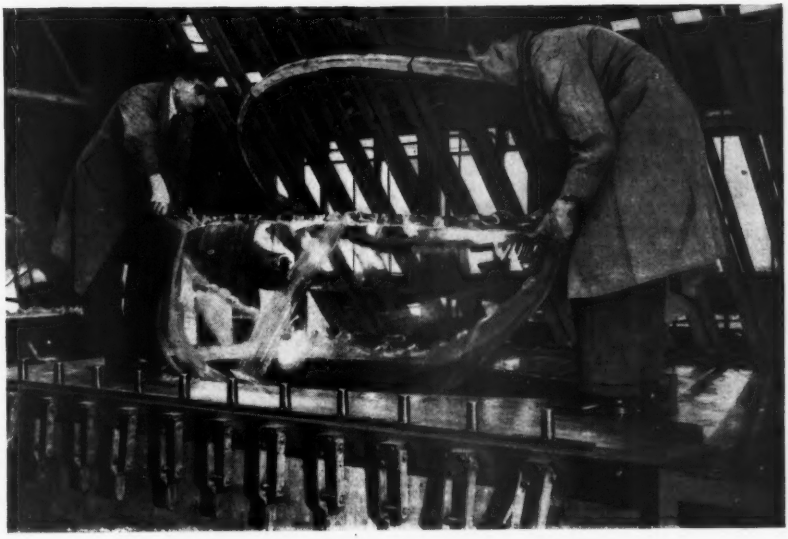
Generally, these fixtures are made of wood—softwood or plywood. The surfaces may or may not be shellac coated. In any case, they quickly become very dirty with swarf and oil. The oil becomes absorbed and cannot be removed by cleaning processes. At the same time, it is evident that clean fixtures must be used for the work after cleaning and finishing, whereas, in practice, after the first flow of work through the production shops, rarely are clean boxes available. Therefore, clean work becomes contaminated with dirty oil. Usually this includes sulphurized cutting oil. As a result, clean brass becomes stained and blackened, zinc plate dirty, silver plate multi-coloured etc., etc.

It is suggested that if the insets are made from phenolic laminated, this annoying deterioration of work can be avoided. Oil does not become appreciably absorbed and the insets can be regularly degreased for its complete removal. The normal trichlorethylene degreaser is satisfactory for this purpose. The outer box can still be of wood if desired.

(To be continued.)

KERATIN—A MODIFIER FOR PHENOLIC PLASTICS

Keratin protein, obtained from feathers, hair, hoofs and horns, has been shown to consist of extended polypeptide chain molecules. Previous technical literature describing the employment of keratin in plastics and fibres is reviewed in a paper by Brother, Binkley and Brandon in "Modern Plastics," March, 1945. The effect of the addition of keratin on flow and cure of phenolic moulding powders and the properties of the moulded parts was determined. An important influence on the behaviour of the keratin added to phenolic moulding compounds was the degree of "calcination" at 210-221 degrees C. before its addition to the synthetic resin. The greater the time and baking, the faster and longer is the plastic flow as determined by the Peakes-Rossi flow apparatus. In performing A.S.T.M. tests on finished parts, it was observed that the keratin-phenolic materials possesses considerably better arc resistance than the unmodified phenolics. A greater colour selection is possible, though water absorption is slightly higher and physical properties lower. In the test formulation 70 parts of phenolic resin were employed with 50 parts of keratin.



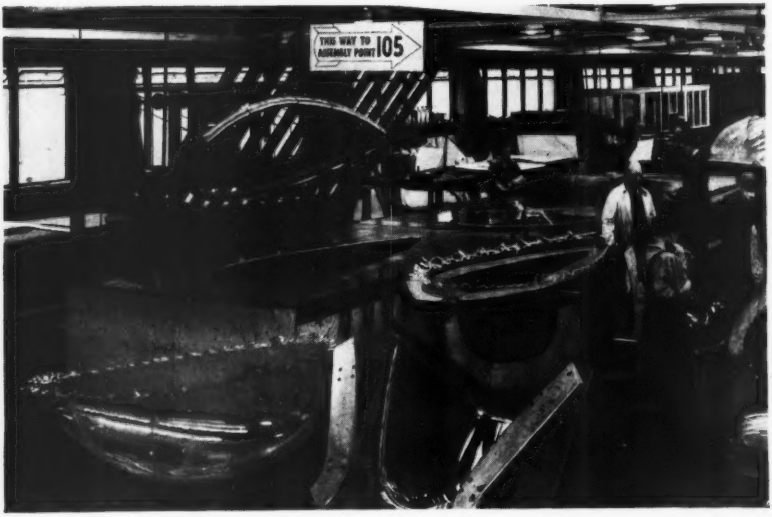
PERSPEX BLISTER

NEAR Preston, in Lancashire, the English Electric Co., Ltd., has been making Halifax bombers for some considerable time, and, in the plastics section of the works, has been producing transparent noses and similar components of Perspex, the I.C.I. methyl methacrylate sheet.

The latest development in this sphere is very much a hush-hush job, but we are able to give some interesting details of it and to mention a method of thermoplastic

(Above) Forming table containing plaster mould and clamping device. The formed sheet is being removed.

(Right) The moulded sheet is trimmed by placing in a former and cutting with the special electric tool seen in the photograph.



General view of the plastics section, showing preheating platform and forming table.

sheet forming we have not seen published before.

The special " moulding " we refer to is termed a " scanner," a teardrop-shaped fuselage canopy stated to be the largest single piece yet attempted for large-scale production. It is 100 ins. by 40 ins. by 30 ins. in $\frac{5}{16}$-in. Perspex.

It is built up from four pieces of the sheet pre-jointed on a large table by a " heat and pressure close dough jointing " method devised by I.C.I. Plastics, Ltd.

The preparatory heating to soften the sheet is carried out on a hotplate directly heated by electric elements manufactured by the English Electric Co., Ltd., and zoned so as to distribute the heat differentially over the sheet in the areas where it is required. During this period, the plastic sheet is covered by a heat-insulating blanket.

When it is in the pliable state, the sheet is eased over to the adjacent " moulding " table. This holds the tear-shaped cavity mould, which is made of plaster and is covered with green billiard baize. The overhead clamping bars are pulled down, secured with clamps to hold the perimeter, and vacuum is applied. No former is necessary, since the Perspex is sucked into intimate contact with the baize lining of the mould.

LECTURES AT KEIGHLEY.—Keighley Technical College is inaugurating a series of lectures on the new industry by Mr. C. R. Williams (assistant works manager, Birkby's, Ltd.), Mr. W. Astle (chief designer for the same firm), and Mr. J. Abbott (manager, mould manufacture, Birkby's, Ltd.).

PLASTIC LENSES.—At a recent court case in Nottingham, it was stated that mine workers refused to wear spectacles fitted with plastic lenses as they soon got dirty. The work was so speeded up that the men did not have time to clean them. Judge Caporn asked why the wearing of protective glasses was not made compulsory in mines and was informed that that stage had not yet been reached. The wearing of headgear is also not compulsory.

World's Industry Employs Plastics

GENERAL ENGINEERING

Sections of thin wire of a gauge too fine to be measured accurately with an ordinary micrometer, are mounted by a special technique in plastics after polishing. Measurements are made by means of a micrometer on the base attached to the usual microscope. ("Scientific American," 1945/172/110.) **Experiments with plastics for drop hammer and hydraulic press punches** used in the forming of sheets of aluminium alloy were begun about two years ago in the Lockheed works at Burbank, California. Very promising results were achieved, and it is predicted that, in future, about 80 per cent. of drawing punches for these materials will be made of synthetic resin base media. ("Machinery," London, 1945/66/277.) **For binding the abrasives** on polishing wheels, a new synthetic cement has been developed by the Michigan Bleach and Chemical Co. It is said to be suitable for all grain-sizes from 250 to 20 mesh. ("Scientific American," 1945/172/58.) **Principles and some applications of high-frequency heating** were dealt with by Dutton in a recent lecture before the Institution of Production Engineers. Demonstrations were given of the effect of preheating plastic powders by high-frequency currents and the glueing of joints. Elements of economy in time and improvement in quality of the product were emphasized. **Replica method widely used in electron microscopy** has been developed by Herschmann, of the U.S. National Bureau of Standards, to provide a new method of evaluating the surface finish of metallic surfaces. A solvent is applied to the surface, and then a clear plastic film (ethyl-cellulose) is pressed on. After drying for about one minute the film is stripped and inspected optically for transparency, which decreases with increased roughness of the original metal surface. ("Mechanical Engineering," 1945/67/19.) **"Faxfilm," a product of the R. D. McDill Co.,** is also marketed specially for a similar technique to that just described. ("Product Engineering," 1945/16/66.) **Working stresses for plastics** must reflect the influence of numerous environmental conditions as well as of variations in manufacturing methods. Delmonte in "Machine Design," 1944/16/99, presents a survey of data on apparent elastic limits, influence of temperature on physical properties, effects of different chemicals on various commercial types of synthetic resin, etc. **Use of special sintered-carbide cutters for machining grooves** for jointing impregnated laminated wood has resulted in greatly increased capacity as, compared with high-speed steel cutters, hard metal tools give fourfold output. ("Production and Engineering Bulletin," 1945/4/56.) **New moulding compound Lucite HM/122** is said to be outstanding for ease and economy in moulding. Faster properties in correctly heated dies permit a shorter moulding cycle. The new material still fully allocated for essential purposes has unusual clarity, brilliance and reflecting properties. ("Scientific American," 1945/172/237.) **A blind rivet marketed under the trade name "Des-Rivet"** in plastics permits one-man operation and blind fastening. It is based on a wedging action, and takes advantage of the flow characteristic of plastic material under pressure. ("Automotive and Aviation Industries," 1945/92/85.) A series of articles on **design of moulded plastics** has been contributed by Prince to the Industrial Plastics Section of the "Tool and Die

Journal." Inserts were dealt with in the issue for January, 1945, page 117, and in the issue of February, 1945, page 119. Threads were dealt with in the issue for March 1945, page 115.

ELECTRICAL

Polydichlorstyrene, an injection moulding compound marketed under the trade name "Styramic HT," retains the low dielectric loss characteristics of non-halogenated polystyrene, but, according to Jones in "Product Engineering," 1945/16/52, has, also, superior resistance to heat. **Micarta 444, a recently developed laminated phenolic thermo plastic,** passes, when heated rapidly to 275 degrees F., through a stage of flexibility and may be drawn without cracking, wrinkling or delamination. ("Electrical World," December 9.) **Plant for extruded plastics, in particular, for wire-covering purposes,** is described by Rolfe in "Practical Engineering," 1945/11/270. The account is mainly based on two machines produced by David Bridge and Co. **Wire for U.S. Army telephone systems** proved in short supply on account of difficulties in producing suitable stranded grades, and also on account of lack of natural rubber for insulation. Buna S is proving most satisfactory for ordinary purposes, whilst, on the lighter gauges of wire used on systems carried by assault troops, polythene and polyvinylchloride are made use of. ("Wire and Wire Products," 1945/20/143.) **Application of aniline - formaldehyde resins** and laminates as electrical insulating materials has been discussed by Codolini in Kunststoffe, 1943/33/183. Aniline-resin products show results more favourable than those given by cellulose triacetate and glass fabric for cable insulation, although manufacturing costs are at present still high.

AIRCRAFT

Fuel cell cavities built into the wings of the Superfortress are provided with protective lining made of flexible sheets of synthetic - resin - impregnated glass fibre cloth. ("Product Engineering," 1945/16/37.) **Plastic - bonded hangar** for large single-engine aeroplanes has, according to "Aviation News" for November 27, been developed by a company producing prefabricated houses. It is anchored to 16 concrete piers, and will withstand winds of hurricane velocity. It is treated outside with aluminium pigmented asphalt base paint. **Metal coatings for plastics** provide components with characteristics not found in either material individually. A general article dealing with many new important applications is contained in "Scientific American," 1945/172/222. Examples are the fire interrupter for a 0.50 machine-gun mounted on certain Curtiss - Wright machines, instrument boards for aeroplanes, electro-plated plastic commutators, sensitive loop ledges for direction finding, and the like. Production technique and some general applications are also discussed. **Fuselage panels for the R-6 military helicopter** are of moulded laminate in order to achieve light weight, high strength, and good insulating properties. ("Prod. Eng.," 1945/16/99).

MOTORS

Models of small intricate mechanisms, such as fuel selector valves, engine-driven hydraulic pumps and the like, are made in plexiglas by the Ford Motor Co. to speed up the training of employees. Working of synthetic rubber tended, in the past, to entail heavier

labour charges than those associated with natural rubber. A new process evolved by the General Tire Co. permits the direct addition of carbon black latex, reducing milling time by 35 per cent. and power consumption by 20 per cent. ("Chem. and Met. Engineering," December, 1944.) **Vinylite elastomers are now used for a variety of important parts in automobile construction** where hitherto natural and synthetic rubbers have been employed. The components affected include distributor, plastic grommets, valve caps, etc. The performance of the elastomers is such that these parts can be expected to become standard in such materials for numerous other products. Types and grades as well as specifications and applications are given by Kelso in "Automotive and Aviation Industries," 1945/92/18.

MISCELLANEOUS

Injection moulding machine by Hydraulic Press Manufacturing Co. is provided with resistance heated strip elements which heat a two - zone chamber. ("Product Engineering," 1945/16/16). Operation of the new high-pressure Chrysler screw - injection moulding machine is clearly described in an account in "Scientific American," 1945/172/82. The special additions of this equipment for making battery boxes and similar high-walled and sub-divided components are enumerated. **Part played by laboratory research in stimulating the growth of the plastic industry** to its present size and importance is treated in a general article in "Scientific American," 1945/172/26. **High precision scale rules for drafting** are made of injection moulded plastics. Triangular relief facet scales are produced within 24 hours by this method, 24 months being at one time necessary to season boxwood scales of the same quality. ("Scientific American," 1945/172/51.) **New Textolite insulating foam** can be formed directly in the space which it is intended to occupy, and volumes up to 50 cubic ft. can be filled in this way. Transmission from liquid to cured foam is a matter of minutes only and no heat is necessary. The material may be cut with a knife or saw and is resistant to temperatures up to 390 degrees F. **"Weldwood"** is the proprietary name for a urea-formaldehyde plastic powder which, when mixed with cold water, gives at once a creamy liquid ready for use as an adhesive. ("Machinery Lloyd," 1945/March 17/17/47.) **Tenite injection moulded plastic binders** for notebooks are being manufactured by an American concern. ("Product Engineering," 1945/16/17.) **Plaskon** 810-12, a newly developed phenolic resin adhesive powder for hot-press purposes, is said to meet the most rigid requirements of water and weather resistance. It is extensible with wheat flour for general purposes. When equal parts of the resin and wheat flour are used, a bond is obtained capable of withstanding three hours' boiling test without delamination. ("Automotive and Aviation Industries," 1945/92/40.) **Recent survey by Klines on advances in plastics during 1944** is contained in "Technical News Bulletin," 1945/February, Pages 9 and 90. **A method of producing synthetic rubber of hard and semi-hard quality** has been developed by processing synthetic rubber with phenolic resin. Durez resin has in the past been compounded with Buna S and Buna N, but mixes with neoprene and natural rubber have been tried; the use of other synthetic resins in this action seems possible. The Durez resin is said to soften the synthetic rubber during processing, but the mixing or loading has proved difficult owing to the peculiar viscosity of synthetic rubber. Phenolic resin is said to reinforce the rubber in a manner similar to carbon black. ("Scientific American," 1945/172/236.) The special **properties and applications of Resorcinol-formaldehyde adhesives** which can be cured at room temperatures or by heating have been described by Rhodes before the A.S.P.I. (See "Production Engineering," 1945/16/135.)

Institute of the Plastics Industry Meeting

Some Recent Advances in Synthetic Adhesives

(Being an abstract of a paper read by Dr. N. A. de Bruyne, of Aero Research, Ltd., before the London Section of the Institute on February 22, 1945, at the Waldorf Hotel.)

DR. DE BRUYNE began his lecture by referring to the comparative newness of the synthetic adhesive in this country, for it scarcely existed before 1937. To-day, it finds itself in a fortunate position. It is independent of foreign material, and, moreover, has been responsible for many significant advances, such as the development of gap-filling U.F. glues, the substitution of melamine for resorcinol in U.F. hardeners, the development of cold-setting phenolic adhesives, and of adhesives for structural metal joints.

The Strength of a Lap Joint

The lecturer then described some of the work carried out by his company on the computation of the strength of a glued joint from its dimensions.

While the average breaking load increases with the width of a joint, it does not increase in proportion to the overlap. Thus, while glued lap joint 1-in. width with a 1-in. overlap may show an average breaking load of 1,000 lb., a 2-in. overlap will give, say, a breaking load of 1,500 lb., or only 750 lb. sq. in. (see Fig. 1). Why this is so was explained by observation of stresses between two elastic tapes sewed together with elastic thread. Pulling the tapes shows that the thread is mainly stressed at the ends.

In a similar fashion, in a glued joint with a long overlap the glue carries most of the load at the ends, while at the centre it is much less stressed. Thus, no considerable increase in breaking load can be expected by increase of overlap. Furthermore, the apparent breaking stress, which is the magnitude of the stress if it were uniform over the whole joint, is less than the true stress existing at the two ends of the joint.

To compute the breaking load of a glued joint we must know the distribution of stress. This can be done, and so we can arrive at the stress of a glued joint.

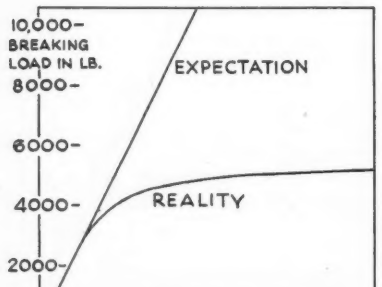


Fig. 1.—The graphs show that breaking load does not increase at the same rate as increase in overlap.

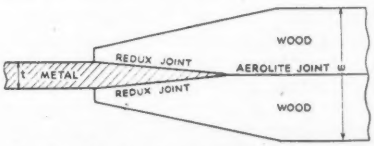


Fig. 2.—The best type of joint is a scarf joint. In joining wood to metal the scarf should be no steeper than 1 in 12.

If "w" is the thickness of the wood and "t" is the thickness of the metal then the joint should be so proportioned that

$$\frac{w}{t} = \frac{\text{Young's Modulus of Metal}}{\text{Young's Modulus of Wood}}$$

Thus since the Young's Modulus of steel is thirty million p.s.i. and that of wood is about one and a half million p.s.i., the thickness of the wood should be twenty times that of the metal. The strength of the joint will be equal to the shear strength of the wood.

Table 1.

	Gap Joints	Initial dry strength	After immersion in water at 70°C. and redrying	After immersion at 70°C. and redrying five times	After immersion at 70°C. and redrying ten times	Dry strength after three weeks
		lb.	lb.	lb.	lb.	lb.
P.F.	Glue No. 1	540	530	350	340	475
	Glue No. 2	560	530	500	490	565
	Glue No. 3	570	500	495	460	560
U.F.	Aerolite 300F. and GBQ ..	625	530	385	335	560
	Glue No. 4	545	275	190	45 (5)	525
	Glue No. 5	585	305	245	195	590
	Glue No. 6	575	275	145 (10)	135 (10)	565

The above tests were carried out to Specification D.T.D. 484 and the figures represent the mean of six tests of dry strength and twelve tests after immersion in water. Where samples have fallen apart during treatment the average failing load has been computed by dividing the aggregate failing load of the remainder by twelve and the number of samples surviving has been given in ( ).

In a straight, tapered joint there is much less stress concentration than in a lap joint, because the cross-sectional area of each member of the joint is proportional to the load it has to carry. An example of such a joint between wood and metal is shown in Fig. 2. Wherever possible, a scarf joint should be used. Analysis and tests have confirmed its efficiency.

Radio Heating and Other Methods

Since radio or high-frequency heating has been dealt with so often, the lecturer did not deal at length with the subject. He showed slides of typical sets and gave a rough rule for estimating the size of equipment. This was that one unit of electricity will heat 1 cubic ft. of wood through 100 degrees C., and shows that quite large radio frequency generators are needed if radio heating is to be used economically in plywood manufacture. Experience has shown that it is better to apply the electrical field parallel to the planes of the glue layers rather than at right angles, because by doing so the heating is localized in the glue layers. This is hardly feasible in plywood manufacture, but can frequently be done in assembly gluing.

Other Heating Methods

Dr. de Bruyne also described a new type of " gun " used for localized heating, and which should be of value in decorative veneering and marqueterie, because it enables the pieces to be tacked in place before pressing. Tests carried out by the Forest Products Research Laboratory for the M.A.P. show that glued joints can be made between veneers 1/50-in. thick in three seconds. It is a useful tool in rubber bag pressing as it is quicker and more effective than a soldering iron for edge-joining veneers.

Although not yet in production, the Gallay process—the electrical heating of glue with a conducting mesh—has given promising laboratory results.

The chief advance in U.F. adhesives during the past two years has been the introduction of glues which, used by the separate application method, give gap joints complying with specification

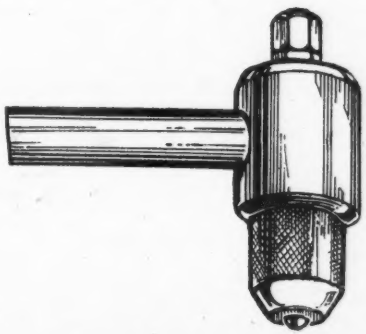


Fig. 3.—Recently developed applicator for separately applied glues. The glue is fed into the head by gravity.

D.T.D. 484 and with characteristics surpassing those previously attainable with U.F. adhesives. Tests carried out by the Forest Products Research Laboratory to specification D.T.D. 484 on behalf of the M.A.P. show, for instance, that after 10 cycles of wetting and drying the average joint strength of 12 specimens was 335 lb.; figures for other U.F. adhesives were 45, 195, 133 lb. The average figure for cold-setting P.F. adhesives under the same conditions was 430 lb.; thus the new type of U.F. adhesives can be said to have strength properties comparable with those of P.F. adhesives, while, at the same time, it is free of their disadvantages. See Table 1.

During the past two years controversy about the merits of mixed versus separate application has continued without any decisive result. Dr. de Bruyne's preference is for separate application, although his firm makes glue for use by both techniques.

A suitable applicator recently developed for separately applied glues is shown in Fig. 3.

Developments in P.F. Adhesives

The past two years have seen the introduction of resorcinal or modified phenolic adhesives which represent an advance over earlier cold-setting P.F. adhesives in that they have a storage life which appears to be of almost unlimited length and that they do not rely on strong acids or alkalis as hardeners. They seem to have every desirable characteristic except low cost.

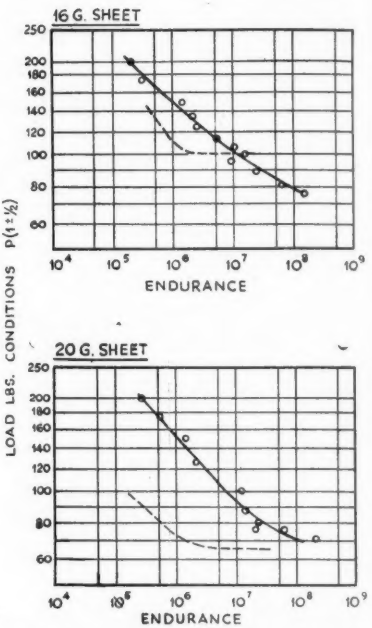


Fig. 4.—Fatigue-S/N curves, "Radux" joints in D.T.D. 390 sheets. (Dotted lines show results from single spot welds on similar materials.)

Typical test results on an adhesive of this type are shown in Table 2.

Metal-to-metal Joints

Perhaps the most interesting innovation in the past two years has been the introduction of synthetic adhesives for joining metals together. The strength of such joints can surpass that of compar-

Table 2.—Summary of Tests on Aerodux 184.

Test	Hardener HR 90		Hardener HR 180	
	Pressure joints	Gap joints	Pressure joints	Gap joints
D.T.D. 484 dry tests	785 lb. (12 tests)	533 lb. (11 tests)	795 lb. (12 tests)	543 lb. (10 tests)
D.T.D. 484 wet tests	725 lb. (12 tests)	—	690 lb. (12 tests)	—
Wet strength after 3 hours in boiling water	640 lb. (12 tests)	370 lb. (12 tests)	700 lb. (12 tests)	400 lb. (12 tests)
Wet strength after 3 hours' immersion in water at 70°C.	580 lb. (12 tests)	440 lb. (6 tests)	680 lb. (12 tests)	500 lb. (5 tests)
Dry strength after 3 hours' immersion in water at 70°C.	770 lb. (12 tests)	530 lb. (6 tests)	737 lb. (11 tests)	510 lb. (6 tests)
Dry strength after 10 cycles' immersion at 70°C. and redrying	686 lb. (23 tests)	550 lb. (12 tests)	—	—

able spot welded or riveted joints. The external surface of the joint is untouched, it is free from surface markings, it is aerodynamically smooth, and ready for painting. The temperatures at which bonding takes place are far below those reached in spot welding. These features are of particular importance in the bonding of light alloys, and synthetic adhesives promise to extend their utility considerably.

Bonding is carried out by the simultaneous application of heat and pressure, and provision must be made for maintaining pressure while the adhesive materials are being compressed and consolidated; a hydraulic press or a spring-loaded clamp is the most effective means of applying pressure.

Metal surfaces must be thoroughly degreased before bonding, and aluminium and aluminium alloys when not anodized should be pickled in accordance, for example, with specification D.T.D.915A. Quite a number of such adhesives claiming to give strong metal-to-metal bonds have recently appeared in U.S.A. One of the most publicized is "Cycleweld"; other proprietary names are "Reanite," "Cordobond" and "Metlbond." The information below has been obtained on the process developed by Aero Research, Ltd., and called "Redux" bonding. However, the following references may be useful to those who wish for further information:—"Cordobond," "Modern Plastics," September, 1944, pp. 103, 194, 196. "Cycleweld," "Modern Plastics," September, 1943, pp. 65-69 and p. 152. "Metlbond," "Aircraft Production," February, 1945, pp. 55-56. "Reanite," "Modern Plastics," January, 1944, p. 123. "Redux" process, "Light Metals," May, 1943, pp. 219-221.

Table 3.

% of Joint Strength at varying Temperature

Metal to Metal	°C.	Metal to Wood
30 %	100	100 %
60 %	80	100 %
92 %	60	100 %
99 %	40	100 %
100 %	20	100 %
100 %	0	100 %

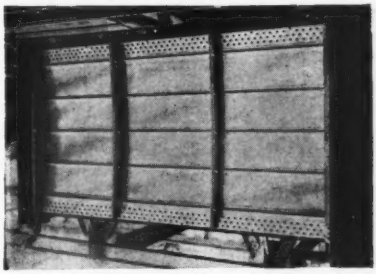


Fig. 5.—This glued panel remained in good condition after "racking" 330,000 times.

(a) Fatigue Strength

Fig. 4 shows how the fatigue strength of simple lap joints (continuous line) compares with that of comparable spot welded joints (dotted line) between Alclad strips $\frac{1}{2}$ in. wide with $\frac{1}{2}$-in. overlap and 20 S.W.G. thick (see Field and Sutton, "Trans. Institute of Welding," Vol. 3, No. 3 (1940), pp. 157-174).

(b) Effect of Temperature

Table 3 shows the effect of temperature from 0 degrees to 100 degrees C. on the static strength. The joints do not become brittle at −degrees C.

(c) Effect of Common Solvents

Common solvents have no ill-effect on the strength of joints.

(d) Corrosion

While the process of bonding does not itself cause corrosion of metals, it does not prevent corrosion from creeping underneath the adhesive layer from unprotected metal outside the joint. Anodized aluminium or Alclad gives good corrosion-resistant joints. Joints made to bare metals should subsequently be given some treatment to prevent corrosion.

Magnesium alloy test pieces chromate treated before bonding and painted with U.P. 4 undercoat and D.T.D. 63A top coat after bonding have shown no deterioration after 10 months' exposure to salt spray corrosion tests.

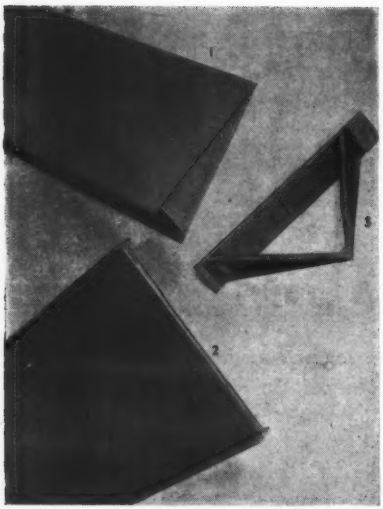


Fig. 6.—The gluing of metal fittings to wood structures with cold setting glues.

Applications of Adhesives for Metals

The applications of such adhesives are multitudinous. Some of them are illustrated in the following slides:—

(a) Aircraft Applications

The aircraft industry has been quick to appreciate a method of bonding which gives an aerodynamically smooth surface with greater strength than can be obtained by rivets. Independent tests by a number of aircraft firms of the comparative strength under compression of panels with riveted and with bonded stiffeners have repeatedly established the superior strength properties of bonded panels. In the bonded panels the skin and stiffener act as one unit, and when failure eventually takes place the skin and stiffener buckle simultaneously with a remarkable absence of tearing.

An interesting practical test, one of many carried out by the de Havilland Aircraft Co., Ltd., is shown in Fig. 5. This panel was racked up and down 330,000 times at a stress sufficient to cause appreciable waving in the panel. At the end of that time the panel was free of defects.

The use of these adhesives solves the problem of attaching metal fittings to wooden structures. Bolts are a notoriously ineffective way of transferring loads to wooden members; by bonding the metal fitting to the wood the load is transferred in the most efficient way possible. It is advisable first to veneer the fitting with wood and then to glue this veneered metal fitting to the main wooden structure with a cold setting synthetic adhesive; this obviates the necessity for applying heat to the main structure.

The gluing of metal components can reduce production costs by achieving in one pressing operation what can only otherwise be done by drilling and riveting.

(b) Motorcar and Cycle Applications

Light alloy bicycles will mean less effort and more acceleration, and the new adhesives promise to play an important part in their successful production. Tests on split-lug and tapered tubular joints between 1 in. and ½ in. O.D. hard-drawn aluminium alloy tubes to specification L 46 and sockets made from heat-treated

Fig. 7.—Pressed-metal door glued together. The photograph also shows a brake-lining and cycle frame similarly treated.

duralumin gave failing loads in every case outside the joint of 1.16, 1.19 tons and 3.24, 3.19 tons, respectively. Tension tests on the tubing gave failing loads of 1.20 tons and 3.35 tons for the $\frac{1}{2}$-in. and 1-in. O.D. tubes, respectively. In no instance did failure occur in the bond; all fractures took place in the tube outside the bond.

Fig. 7 shows a pressed-metal door entirely glued together. It is rigid and strong and free of all weld marks. The joint is hermetically sealed.

Brake and clutch linings bonded to metal shoes have given excellent results both on test and in over two years of practical experience. The nature of the load (approximating very closely to pure shear) is favourable to glued joints, and the strength is sufficient even at the high temperatures occasionally developed.

(c) Building Applications

Aluminium window frames are easily made by bonding with a synthetic adhesive. We can expect to see many more aluminium windows in anodized and dyed finishes in the near future; the lightness and strength of aluminium alloys and the ease with which they can be extruded makes them specially suited to such an application.

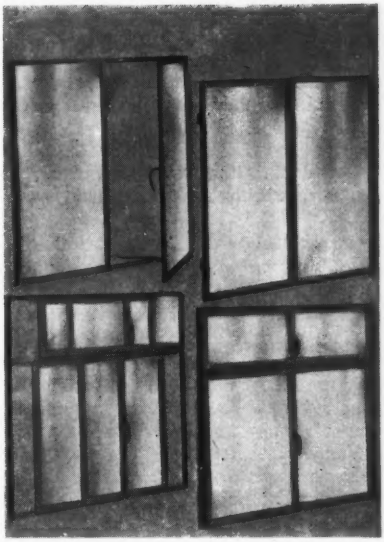


Fig. 8.—Aluminium window-frames bonded with synthetic adhesive.

Knife handles with the "scales" bonded to the knife are attractive and strong.

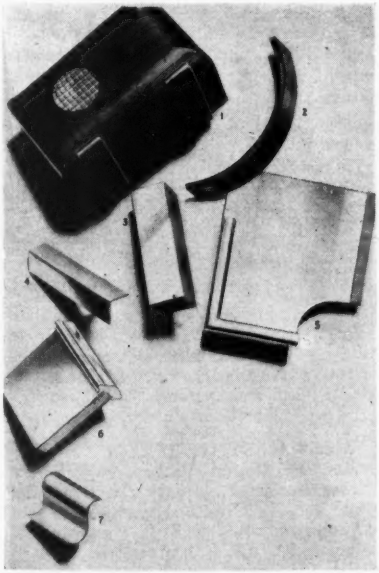


Fig. 9.—Radio cabinet of sheet steel bonded to birch veneer.

(d) Application of Veneered Metal.

When wood veneer is securely joined to metal sheets a composite material results which will retain its shape when bent and which can subsequently be stuck with a cold-setting synthetic adhesive. It has some of the good qualities of both metal and wood. The radio cabinet shown was made from a piece of flat sheet metal to which a birch veneer was bonded; the steel was cut to a template, bent up into a box, and then soldered on the inside of the corner joints. It is a screened metal cabinet with an external wood facing.

The bonding between wood and metal given by the new adhesives is of quite

a different order from that exhibited by ordinary metal-faced plywood. It is so strong that flat aluminium-faced plywood can be rolled to curves of fairly small radii without disrupting the bond. Tests to destruction of such composite panels always show failure in the wood.

Veneered metal is a material which can be put to innumerable uses.

One obvious use is the strengthening of wooden structures with metal gusset plates and angles. Box corners can be strengthened by cementing protecting angles of veneered metal with a cold-setting synthetic adhesive.

Attractive picture frames, mirror and tray mouldings can be made by bending veneered thin stainless steel or anodized aluminium sheet round a wooden batten.

Veneered metal makes it possible to veneer with metal, and the strength of the bond far exceeds that of the underlying wood.

Laminated wooden furniture can be greatly strengthened, stiffened and made more serviceable by cementing veneered metal strips to the top and bottom surfaces of laminated bonds. The flexural rigidity can be increased by such means without increase in weight. Similar principles can be applied to the construction of tennis rackets and golf clubs.

(e) Miscellaneous Applications.

These adhesives have many applications in engineering. They have been found useful in bonding "hard metal" tips to tool shanks and by eliminating the necessity for brazing in a reducing atmosphere extends the utility of "hard metals" such as tungsten carbide.

Fig. 10.—The gluing of golf heads and hafts.

Laminated rotors of electric motors can be bonded into a homogeneous block; the adhesive is a good insulator, and construction is simplified and performance improved by the elimination of rivets or nuts and bolts. This procedure is particularly attractive for electric clock movements.

Adhesives promise to be useful in securing liners of bearings, particularly of the self-oiling type.

FURFURAL RESINS

Delmonte in "Plastics" (U.S.A.) Vol. 2, p. 60, February, 1945, reviews the manufacture of furfural from oat hulls and corncobs. The chemistry of the polysaccharides is dealt with, and the derivation of furfural from pentosans is pointed out. Reactions with phenol indicate an advantage for furfural over formaldehyde, in the absence of initial water, though some is formed by condensation. Flow properties and moulding characteristics of the phenol furfural compounds are compared with phenol-formaldehyde types. Reactions with cresols are also evaluated. The preparation of urea-furfural resins is described and the mechanism of its polymerization reaction traced. Aniline-furfural resins in plastics from waste vegetable products, and furfural modified polyvinyl alcohol resins are discussed. Preparation of furan and furfuryl alcohol are indicated, as well as their physical properties.

GERMAN SYNTHETIC RUBBER

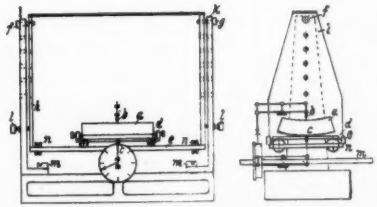
Germany's largest synthetic rubber plant is in Allied hands. Up to a few days ago it was turning out 6,000 tons of synthetic rubber a month, until it was captured undamaged by the U.S. Second Division.

It covered four square miles of ground outside Schkopau, south of Halle, and employed 15,000 workers, half of them imported slaves.

Swelling of Plastic Bearings

Condensed from an account by H. Keller in "Kunststoffe" 1944/34/27. Particularly for tailshafts for ships, bearings are used consisting of a number of rectangular strips held together in a suitable housing by means of wedges. In place of the wood formerly used for the purpose, phenolic resins have, for some time, found extensive employment. Swelling phenomena associated with varying types of resin are of importance in determining satisfaction in service. The behaviour of various resins and fillers is shown to differ markedly.

THE principal problem of interest connected with plastic-lined bearings formed by building up a system of plastic strips inside a suitable housing lies in the tendency of the strips to vary in thickness with time and under varying conditions. Alterations in a longitudinal direction or in width, provided such materials do not exceed certain limits, are of little interest as they do not affect bearing play. It should be borne in mind immediately that synthetic resins with their associated fillers do not constitute homogeneous masses, hence accurate predetermination of swelling capacity is fraught with difficulty, particularly if as a basis for the determination the experimenter takes volume alterations.



Front and side view of the author's apparatus for periodic measurement of swelling: a, test piece; b and c, points; d, traversing carriage; e, carriage guides; g, supporting pins; h, cradle; k, stand; l, spring damping; m, rails; n, rolls.

Measurements of the internal and external diameters of hollow cylindrical test pieces as adopted by a number of workers gives reasonably accurate results if the sample chosen be sufficiently small. Large components, however, particularly when they are not in the form of a single pressing but are investigated by sections extracted from them, require an endless number of measurements before reasonable accuracy can be assured, as a mean value for swelling must obviously be arrived at.

It was with these points in mind that the author devised the test periods used for the investigations to be of a steel cradle capable of moving in two directions at right angles to each other. On this the component rods from the built-up building were mounted and to the surface of the components was applied the contractor of a suitable dial gauge. Movements of the cradle enabled accurate records to be made of the non-uniform swelling which occurred in both a transverse and a longitudinal direction to the mass of the specimen. The test pieces chosen were 18 to 24 mm. thick supplied in part as samples by the manufacturers and in part taken from deliveries designed for use. The following groups were examined:—

(1) Cotton fabric filled; A—Clippings of coarse and fine fabrics; B—Woven fabric of coarse and fine texture.

(2) Coarse and fine cellulose-base textiles.

(3) Cellulose fillers.

In the first series of tests all specimens were immersed in distilled water at room temperature and in the second series of tests in distilled water at 18 degrees C. At fixed intervals during the immersion period the thickness of each specimen was measured at 63 points, being subjected first to careful drying with filter paper. In order that a clearer idea might be gained of the effect of swelling on the bearing formed, solid models were constructed on the basis of the measurement obtained and time thickness curves were also drawn for each specimen. The complete data yielded interesting information on the course and progress of swelling. The process commenced as might have been expected at the outer zones of the specimens which were subjected to attack from both sides.

Swelling in the interior of the test pieces occurred at a more or less fixed interval of time from that taking place on the exterior of the bars. After quite a short time many of the plastic pieces showed distinct high spots; these on continued immersion, grew more pronounced. In each group of materials examined marked variations occurred. In the case of those materials with textile cutting fillers, one specimen underwent a slight shrinkage during the first few hours of immersion. This phenomenon being observed also with another example in which, however, the shrinkage was immediately followed by swelling. Most swelling was observed in these materials after immersion for 936 hrs., after which the specimen began to regain its normal form between periods of 1,848 hrs. and 372 hrs. it varied within small limits. Certain of the specimens betrayed more markedly than others the formation of definite high spots, and over the whole range of textile-cutting-filled materials a variation of swelling as much as 200 per cent. occurred.

In the case of cotton textile laminates maximum swelling was of a considerably lower order than that determined for plastics filled with textile cuttings, and in certain instances was so small as to be almost negligible. In the case of other specimens in this group which had an initial exhibited marked swelling at the edges, the differences between edge swelling and that occurring on the surface was still very marked even after 3,000 hrs. immersion. Some unpredictable variations were observed between specimens with coarse and fine textile laminates respectively. In one instance, no appreciable differences were observed between the coarse and the fine laminate, whilst in another 2,000 hrs. immersion gave with the fine textile four to five times as much swelling as in the case of the coarse textile.

Those materials filled with cellulose base material (group 3) showed less swelling than test pieces with cellulose-base laminates. In so far as the course of swelling with time is concerned it was shown that obvious difficulties would occur in deriving an arithmetic mean from individual measurements on given test pieces. Considerable differences, however, did emerge between the marked swelling which occurred in the outer zones of the test pieces and that of a less-pronounced nature which took place in the interior. Previous investigations show that given sufficient periods of immersion swelling in the interior zones equals that occurring in the exterior. However, the author's work indicated that even after 4,000 hrs. immersion no balance was achieved between interior and exterior swelling.

In order to accelerate the determinations it is frequently suggested that the swelling tests be conducted at elevated temperatures. This method, however, presents many disadvantages in the case of the author's investigations carried out at 80 degrees C., the types of swelling curve obtained ran parallel to those for room temperature, the only difference being that the swelling was more marked and that it took place more rapidly. As the period of immersion was prolonged, however, interior swelling caught up more rapidly with exterior swelling than in the case of those tests conducted at room temperature.

Further immersion resulted in still further increase in the interior swelling of the specimen, so that whereas in the case

of room temperature tests curves exhibited minima in this respect, those curves for elevated temperature tests showed instead maxima. This phenomenon can only be explained by assuming that after sufficiently intensive reaction with water the exterior material of the test pieces undergoes subsequent shrinkage. Between the centre of the test pieces and the outer layers it is to be presumed that shrinkage effects are masked by residual swelling. Similar swelling followed by subsequent shrinkage has been observed in the case of oil-lubricated plastic bearings.

From the author's records of the course of swelling at 80 degrees C., it is shown that swelling begins rapidly and somewhat naturally reaches a maximum after a shorter period of immersion than in the case of tests carried out at 20 degrees C. In spite of the apparent limitations of high temperature tests of this sort these investigations appear to indicate that in numerous instances such high-temperature tests enabled quite an accurate qualitative picture to be obtained in the course of swelling of a test piece clearly as valid as that obtained at room temperature but in a much shorter time. It has already been noted that the specimens used in this research vary in thickness between 18 and 24 mm. to determine the effect of this variation on any swelling which might occur. On the preliminary tests were carried out curves of identical materials deliberately cut to various thicknesses.

This preliminary examination showed that within the limitations of time observed in this work thickness variation did not effect swelling capacity. This observation agrees in general with the main findings of the work which indicate that swelling is primarily a surface phenomenon; the effect on the interior of the mass being either of a lesser order or occurring much later in the course of immersion. In view of the fact that plastic materials of the type investigated are as has been studied in homogeneous materials and, furthermore, even within specific groups, show marked differences in behaviour on immersion, it is not possible to draw any general conclusions. For this reason it is recommended that the requisite curves for each sample tested be studied in the author's original paper.

Consideration of certain of the practical aspects of Keller's investigation leads to some criticisms. By implication, the tendency is to compare the dimensional stability of the compound plastic bearing with that of a conventional metal bearing. Clearly, in this case, plastics tend to emerge in a somewhat unfavourable light—unfavourable, that is, to the extent that provision must be made for any change of shape which may occur in the strips after prolonged immersion, a state of affairs not likely to arise with metal. Of more direct importance, however, is the fact that the author's experimental procedure does not take into account the effect of the load to which the bearing is subjected in practice.

Assuming that the weight of the shaft will not inhibit swelling, it would seem reasonable to suppose that it will, at least, alter the distribution of swelling and, in particular, have a marked effect on the occurrence of "swollen" high spots. Thus, in an actual shaft bearing with the shaft in position, the overall effect of immersion might, in the most favourable circumstances, be to give a uniform diminution in bearing clearance. Here again the problem arising is less acute than might at first sight appear. For a 10,000-ton ship with a 20-in. diameter shaft, a minimum clearance of $\frac{3}{8}$ in. would certainly be provided in the first instance. Before the strips were renewed, clearance in normal circumstances would have increased to something in the order of $\frac{1}{2}$ in., thus there is little chance of undue pressure arising.

It might well be that the concomitant of swelling, namely general distortion of the strips, would lead to their early breakdown, but this again is a factor which can only be determined under running conditions under load; measurements under non-load conditions for the very massive components under discussion can bear little relationship to actual practice.

Principal Limitations of Dielectric Heating

We have been forwarded the following valuable notes by Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pennsylvania. They have been compiled by Carl J. Madson, Electronics Engineer of that company.

WITH the popularity of high-frequency heating growing by leaps and bounds, it is desirable to stop for a moment now and then to take stock of the state of the art. This can best be done by breaking down the broad view and reviewing only a narrow phase at a time. This paper is concerned with only dielectric heating (heating of materials by a varying electric field), and reviews the major limitations that prevent universal application.

In considering these limitations, it must be understood that almost all of them are interlocked, to some degree, with each other. Hence, in discussing each individually, it is well to remember these interrelations when considering an actual application.

Cost

High-frequency energy is not a cheap source of heat. In terms of dollars per KWH, it will cost approximately $0.025 to $0.04, including direct operating cost, maintenance and amortization.

It becomes economical by virtue of one or more of these factors:—

1. It produces a result not possible by other methods of heating.
2. It increases the speed of a process and saves labour and/or overall equipment cost.
3. It produces or confines the heating in the part or point where needed, thus reducing overall power consumption.
4. It is clean and compact.
5. It reduces rejects, or improves the production quality of a product.
6. It is flexible in its application to a variety of operations, processes and products.

These factors are often of sufficient importance to make an application economically attractive.

Material

Dielectric heating is applicable only to materials normally considered poor conductors of electricity or insulators. When the electrical resistivity of a material drops below 1,000 ohm.-cm., it is usually possible or necessary to use some technique other than dielectric heating. The state and characteristics of the material have considerable influence on the division point, changing it as much as 10 to 1.

A convenient formula for calculating the heating in dielectric materials is given by:—

$$W = \frac{1.41\, A\, f\, E^2\, e'' \times 10^{-12}}{d}$$

where W = rate of heating in watts.
A = area of electrode in sq. ins.
d = thickness of material in ins.
f = frequency in cycles per second.
E = voltage RMS.
$e'' = \text{loss factor of material} = e' \tan\delta$.

The following paragraphs discuss briefly each of these factors.

Dimensions

The dimensions of the piece of dielectric material are important in that they may influence an application as to frequency, rate of production or electrode design.

In general, dielectric heating becomes attractive when the thickness of the material is sufficient to make it difficult to heat the material throughout by conventional means. In terms of inches, this

will vary with the thermal conductivity of the material.

The thickness of the material must be reasonably uniform if uniform heating is desired. If the work is of such shape (for example, wedge shaped) that two pieces of material can be placed in complementary positions and the resultant thickness be uniform, the material will heat evenly. Special technique in electrode design and arrangement may sometimes be used when dealing with irregular thickness materials. The relation of thickness and voltage will be discussed under voltage.

The area of material to be heated will limit the frequency which may be used, in two ways.

The capacitive reactance of a large area may become sufficiently low as to make tuning of the load extremely difficult if not impossible. The currents involved may also reach magnitudes difficult to handle.

The length of the load may be such as to produce standing waves. This will be discussed further under frequency limitations.

Sometimes it is possible to scan the material, thus reducing the electrode area to a value which permits convenient adjustments and frequencies sufficiently high to produce desired rate of heating.

Occasional applications are encountered where a particular area can be heated if the material is stacked, increasing the thickness dimension and thereby reducing the capacity of the load.

Frequency

In general (since the amount of energy introduced into the material is proportional to frequency) the desire is to use as high a frequency as possible. A compromise is usually necessary, however, due to one or more limitations.

The effect of large areas and low capacitive reactance was discussed previously.

The length of the material may be such as to produce uneven heating due to standing wave effect. The higher the frequency used, the greater the probability of unequal voltage distribution over a given length or area. If the longest dimension of the electrodes is a small fraction of a wave length, or if the material is scanned, this effect is minimized. Ordinarily, if the longest distance from the point of connection to the edge or corner of the high-voltage electrode is less than $\frac{1}{16}$ of a wave length, very little trouble will be experienced. Heating will be sufficiently uniform to produce a variation of less than 20 per cent. over the area involved. In some processes, this may be intolerable, restricting the maximum frequency (or maximum dimensions of the work) to a still lower value.

The maximum frequency which can be used without exceeding the above variation in heating can be determined from the formula:

$$f = \frac{62.5}{d\sqrt{e'}}$$

where f = frequency in megacycles.

d = maximum distance from point of connection to edge or corner of high-voltage electrode in feet.

e′ = dielectric constant of material (specific inductive capacity).

Another limitation occasionally encountered is that of generator design for high power at high frequencies. From a practical viewpoint, at the moment it appears undesirable to use frequencies above 20 megacycles when powers above about 20 kw. are involved.

Voltage

The power input to the material is proportional to the voltage squared. Hence, if the voltage is increased sufficiently, considerable power can be supplied to the work at relatively low frequencies. Two factors limit the voltage which may be applied.

The total voltage between electrodes should be kept under 15,000 volts. It is not impossible to use voltages above this value, but the additional precautions necessary to avoid corona and arc-overs are often more expensive than some other compromise of the engineering factors.

The voltage gradient, that is, the voltage per inch, permissible across the material, may be a limiting factor. The radio frequency voltage which will puncture a given dielectric material is generally much lower than the 60-cycle voltage which a material will stand. It appears desirable to keep the voltage gradient below 2,000 volts per inch in porous materials and less than 5,000 volts per inch on less porous.

Another type of voltage limitation may be reached in some applications where it is impossible to have the electrodes in contact with the material. This gives rise to a condition in which the space between the electrodes is occupied by two materials of widely different dielectric constants. The potential distribution in this case may be such as to cause a breakdown of the surrounding medium (usually air).

Loss Factor

This is a term commonly used to express the degree to which materials will absorb energy by dielectric heating technique. It is easily measured by means of proper equipment. Referring to equation (1), it is obvious that as the loss factor approaches zero, it becomes increasingly difficult to transfer power into the material. A practical lower limit in the loss factor, of materials which can be heated effectively, appears to be between 0.005 and 0.01. Pure polystyrene, quartz and certain other low-loss materials have loss factors considerably below this value and are exceedingly difficult to heat by dielectric methods.

The upper limit probably blends into the range where the material becomes sufficiently conductive as to respond to inductive fields, although some skin effect will probably be noted before this limit is reached.

Electrodes

A whole treatise could be written on electrode design. One point I wish to cover in this discussion is the fact that heat is not generated in the electrodes to any appreciable degree by the dielectric heating process. The electrodes may be heated by heat transfer from the dielectric material being processed. Often this is undesirable due to the temperature reduction of the adjacent material and may become a limiting factor in some processes. Various simple methods are in common use to minimize this effect.

Summary

Dielectric heating is a very useful tool in industry, one which is finding new applications every day. However, as with any tool, there are certain limitations which prevent its promiscuous application to all types of problems. By realizing these limitations, and the series of compromises often necessary, a careful analysis will permit the average electrical engineer to apply it intelligently to work which it can do well.

ASSEMBLY GLUING

That remarkably useful "Manual on Assembly Gluing" has just been re-published with additional notes by the Society of the Plastics Industry, Inc., of 295, Madison Avenue, New York 17, N.Y. Its function is to promote the proper use of synthetic adhesives for assembly gluing, and it does this job admirably.

The manual is very well illustrated, and is written in simple language with technicalities cut to a minimum.

The contents include:—Adequate descriptions of the raw materials—phenolic, urea, melamine and resorcinol resins; the function of the glue; gluing technique which comprises storage, preparation of wood, mixing, working life, spreading and assembly time; pressure—mechanical, hydraulic, fluid, semi-fluid and dead weight methods; methods of heating—hot platens, oven heating, high frequency, resistance heating, infra-red heating, boiling water or steam-bath; conductive glue line and conductive rubber.

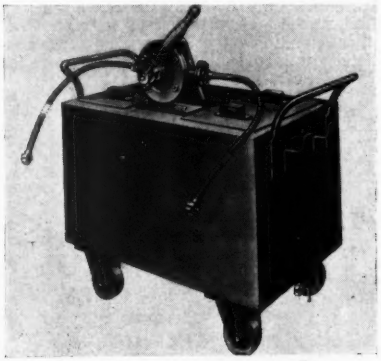
There is also a useful glossary of trade terms used in the industry, and a list of 15 American manufacturers and suppliers of raw material. The price is one dollar.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

LUBRICATING OIL PRODUCTION.—Standard practice in modern technical establishments is to purify, at intervals, the lubricating oils and other lubricants, such as cutting oils, honing fluids and grinding coolants. The dirty oil is taken to a central oil purifier or oil-reclaiming plant and cleaned, and in this way a great economy is obtained as regards consumption of oil, while the net results also are much more efficient, since on all-the-year-round performance the average purity of the oil and, therefore, its lubricating qualities, are maintained at a high figure.

Hopkinsons, Ltd., Huddersfield, have available interesting portable oil tanks for



use with their well-known range of centrifugal oil purifiers. One standard tank equipment, constructed of steel plate, is of rectangular shape, 3 ft. long, 2 ft. wide and 2 ft. deep, carried on swivel castors with rubber tyres, and pushed by hand. The tank has a total capacity of 75 gallons and is divided into two separate compartments, each of which has a loose lid on the top, being fitted also with a hand-operated semi-rotary pump having two lengths of narrow diameter flexible metal hose attached of any desired length.

One of the compartments is filled with clean oil and the tank pushed over the floor to the equipment being lubricated. From the sump or tank of the latter the dirty oil is allowed to run by gravity, if the outlet is above the inlet of the portable tank, or pumped by the hand pump, into the empty compartment, and is then replaced by the clean oil from the other compartment, using also the pump for this purpose, after which the apparatus is pushed back to the oil-reclaiming equipment. The whole arrangement is neat and simple, and various other sizes are available, both smaller and larger, and the firm make a complete range of centrifugal oil purifiers.

Essentially all the machines consist of a bowl containing a pack of thin metal separation cones or plates, assembled one above the other on a central tube with a conical base. The bowl is carried on a vertical shaft running on ball bearings, and the drive is by worm gearing from the ball bearing of the horizontal shaft, so that the bowl is driven at a speed of about 10,000 revs. per minute in the case of the smaller machine and at about 7,000 r.p.m. in the larger units. Also the standard driving arrangement is by flexible coupling from a fractional h.p. motor, mounted on the machine baseplate, operating the horizontal worm-wheel shaft through a centrifugal clutch. The vertical spindle has a special type ball bearing at the lower end of the housing, whilst at the upper end is a second ball bearing, the housing of which has a rubber buffer for "centring," whilst allowing any slight lateral movement when the bowl becomes loaded with impurities. The general design and workmanship is of the firm's usual high-grade character, and these portable tanks are a particularly useful accessory.

REDIFFUSION RADIO HEATING EQUIPMENT.—Many firms interested in developing radio-frequency heating technique in their own factories have found it useful to commence work with a set of moderate power, but sufficiently flexible to carry out a wide range of experiments.

This field is well served by the Redifon R.H.2 (Rediffusion, Ltd., London, S.W.18), a considerable number of which have been installed during the past year for such diverse uses as welding P.V.C., rapid glue setting, preheating moulding powders, vulcanizing rubber, drying latex, softening

P.V.C. chips, Perspex and other thermoplastics, eddy current heating of small steel articles, treating asbestos compounds.

The output of the standard model exceeds 250 watts at a frequency of 50 megacycles per second.

As an indication of the R.H.2's capabilities, it may be taken that 2-3 oz. of standard moulding powder (preforms) can be plasticized per minute, and glue line areas up to 100 sq. ins. set in five minutes.

The complete equipment comprises the radio-frequency generator itself, a variable inductance matching unit and 6 ft. of screened concentric cable. The matching unit may be plugged directly into the generator output socket, or used with the cable at any distance up to 6 ft. In general, the leads from this unit to the work must be as short as possible.

Features of special interest are the very robust ironclad main switch with enclosed fuses; efficient radio-frequency filters in mains input circuit; three-pin socket in H.T. transformer primary circuit, for connection to remote control or heating chamber safety interlock; two-pin socket for remote anode current meter when work is away from the radio-frequency generator itself; strong steel case; efficient ventilating system.

Controls are very simple. Apart from the main switch there is a three-way H.T. switch for "off," "quarter-power" and "full power," allied with a variable adjustment for intermediate settings. Green and red lights indicate when filament and H.T. circuits respectively are on. The variable inductance matching unit covers a wide range of load capacities, optimum setting being indicated by the anode current meter on the generator panel.

A screened experimental heating chamber, giving full access to the specimens and fitted with a 6-ft. screened lead for interlocking the removable cover with the radio-frequency generator H.T. supply, is available at a small extra charge.

Standard mains input: 180-250 volts a.c., 50 cycles, about 650 watts.

Weight: 112 lb.

Overall dimensions of generator: 20 ins. by 18 ins. by 13 ins.

Length of standard concentric cable: 6 ft.

Size of matching unit: 9¼ ins. by 5¾ ins. by 4¾ ins.

Valves: Two Type 813 oscillators, two Type U23 rectifiers.

GERMANY AND POLYTHENE.—Mr. Charles Peat, Joint Parliamentary Secretary of the Ministry of Supply, was asked in the House of Commons to determine whether Dupont de Nemours Inc. had passed on to Germany information received from Imperial Chemical Industries, Ltd., regarding the manufacture and uses of polythene. The American company has replied denying any disclosure to Germany, and insisting that all information on polythene has been completely protected for the exclusive use of the United States.

E. K. COLE, LTD., announce that Mr. W. W. Syrett has joined the company as export manager. Mr. Syrett is well known in the City, as he was previously foreign manager of one of the clearing banks.

INTERNATIONAL COMBUSTION, LTD.—Lord Margesson has accepted an invitation to join the board of this company, which is world famous for the production of grinding and separating plant, as well as combustion apparatus.

ROANOID PLASTICS, LTD.—The telephone number of the company at King's Road, Tyseley, has been changed to ACOcks Green 2816.

THE FURANE PLASTICS AND CHEMICALS COMPANY established its office and manufacturing plant at 5,233, West San Fernando Road, Los Angeles 26, California, on March 1, 1945. This company has been organized to produce plastic materials and various chemicals derived from furfural. Initial production will be devoted to the preparation of high-strength coldsetting adhesives for plastics and rubber products.

The company will also make available in the near future a new liquid, thermosetting

casting resin, which is distinguished from other casting resins in that it is activated by mild alkaline catalysts and may be cured at relatively low temperatures.

Mr. John Delmonte, Technical Director of Plastics Industries Technical Institute, will act as consultant to the company.

BRITISH XYLONITE COMPANY, LTD.—The report of the Directors, together with balance sheet, profit and loss account for 1944, has been published. War and A.R.P. expenditure has been written off and the Company and its subsidiaries in the U.K. have provided for all tax liabilities. The net profit is £33,359. On March 29, 1945, the Directors decided to pay second interim dividends of 2½ per cent. on the preference shares and 7½ per cent. on the ordinary shares, making 5 per cent. and 10 per cent. for the year respectively. These take the place of final dividends.

THE DAILY DOSE

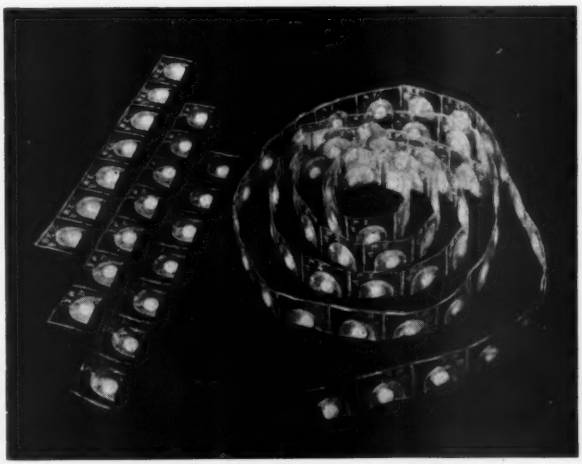
Polythene Aids Fight Against Malaria

This is a sample of the way the anti-malarial drug, mepacrine, is packed in polythene for use by British and Allied troops in the jungles and swamps of the Far East. The drug and its packing represent a double triumph for British chemical research and manufacture.

Mepacrine was produced by I.C.I. to replace quinine, from which Britain was cut off by the Japanese capture of the East Indies. It was found, however, that mepacrine tablets dissolved or deteriorated in the damp heat of tropical jungles. An entirely new method of packing therefore had to be devised and packing experts tried all ordinary materials without success. Polythene, the flexible plastic whose discovery by I.C.I. is one of the major scientific achievements of the past 10 years, was then successfully introduced. It can be produced in thin flexible sheets which are both waterproof and retain their flexibility over temperatures varying from that of ice on the one hand to boiling water on the other. Polythene had never before been used as a packing material, but the most rigorous tests showed that not only was it unaffected by tropical heat, but that the mepacrine tablets wrapped in it could be left lying even in salt water for months and emerge as fresh as when they were packed.

The two next important problems were how to get the tablet into its individually sealed compartment in the ribbon of polythene, and how many millions of tablets a week could be thus wrapped. This is where Genatosan Limited came in. This firm had the only suitable machinery for the work available in the country, and it was found that after slight adaptations these could take a special grade of polythene film only one two-hundred-and-fiftieth of an inch thick.

A week's supply at a time, a strip of seven pockets, is issued to the men on the Burma front. Each day one pocket containing the daily dose can be torn off the strip, leaving the rest safely protected from air, heat and moisture in polythene. The problem of ensuring that adequate supplies of mepacrine can be carried by troops in the most difficult campaigning conditions or stored for long periods in tropical countries has been solved by British inventiveness, chemical research and engineering skill.



Planned Mould Maintenance Service Aids Economical Production

Part XII

By W. M. HALLIDAY

A discussion of mould venting technique for improving the quality and production of mouldings, coupled with trouble-free operation of moulds, especially those intended for the injection process.

The presence of pockets of trapped air, or gases given off by the material, or the retarded expulsion of same from mould cavities, often constitute serious obstacles in the way of securing homogeneous articles.

Not only is the finished moulding apt to be unsound in respect of its internal structure, but its external surfaces may lose their smoothness, detailed figuring, and sharpness. Weakened components may also result from such causes.

Badly vented injection moulds not only entail slower production, weak or faulty mouldings, but also give rise to a number of operating troubles associated with the mould demanding the skilled attentions of the maintenance toolmaker.

In this section, methods of venting will be examined, and undesirable forms remarked, followed by illustrations of more preferred ways of air-venting, which may essentially be regarded as effective safeguarding measures aimed at better protection of mould mechanism.

IN all those forms of plastic moulding production employing moulds containing the requisite cavity shape to fashion the article desired, whether of the compression or injection type, usually some amount of air, or liberated gas, will have to be expelled from the cavities before the plastic material is able completely to fill same.

This is more prevalent in the case of injection moulds than in those used in compression moulding, although in respect of this latter type of mould where an article has to be manufactured having undercut portions, or deep apertures, trapped air may cause troubles.

When the article has to be made as an injection moulding, difficulties due to trapping of pockets of air or gases are likely to be increased even though at first glance one would imagine that sufficient clearance facilities exist for the exit of air, etc., along the parting-line surfaces, and other matching or fitting lines formed by the assemblage of the various component parts of the mould.

It should be borne in mind that the parting-line faces of the main mould blocks of an injection mould should be closely bedded together to ensure effective sealing off, otherwise additional flash may be caused on the finished product, and in view of the high pressures now normally employed in this method of moulding, an opening between mould surfaces exceeding .003 in. will permit plastic material to enter. Therefore all joints which have to be sealed should fit closer than this amount, and moreover the main blocks when closed together in readiness for the injection charge should be powerfully clamped to prevent slight opening along the parting-line when the injection plunger operates.

The major portion of attention and space of this present section will, indeed, be devoted to the consideration of venting technique as applicable to injection moulding since the main difficulties of the maintenance engineer arise in connection with this class of mould, but before proceeding to that study it will be necessary to deal with a few general points concerning the venting moulds used in the compression process.

Venting Compression Moulds

It has already been mentioned that usually no serious difficulty is encountered in respect of the evacuation of either air or liberated gases, and troubles should

Making sparks fly!

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only arise in the case of mouldings of exceptionally awkward configuration, or multi-impression moulds, since generally the essential characteristics of compression moulding conspire to facilitate the ready escape of air.

Briefly enumerated, those characteristics are as follow:—

1. Moulding pressure. Fairly high ram pressures are employed in this method, with the result that any air contained in the cavity of a closed mould will become compressed severely, occupying finally anywhere from 1/200th up to 1/450th of its atmospheric volume. It will thus be seen that a very great expulsion force is actually applied to any resident air pocket left in the cavity, this normally being sufficient to expel the air through joint crevices, slight clearance between ejector rod and its guide hole, cores and their fitting within blocks, etc.

2. Normally the speed of travel of the press ram when compressing the powder within the mould is slow enough to permit due time lag for the escape of air through such mould interstices.

3. Then, further, when the material has become plasticized within the cavity, a sufficient time interval usually occurs whilst the chemical reaction and polymerization takes place during which pressure subjected air streams or pockets can be dispersed and, at any rate, cleared from the mould cavity.

4. Very often, too, the shape of the moulded article is conducive to ready escape of air because generally simple designs and straightforward shapes only are compression moulded. This means that the moulds likewise are nearly always of simple design and construction, possessing few cores, or cross located portions, undercuts, or awkwardly situated inserts, to mention but a few of the common features likely to lead to trapping of air within the cavity.

Therefore it may be generally stated that the compression mould designer in the normal run of designs has little need to resort to special, or additional, venting provisions, in the way that it will be seen later is very often required by the needs of the injection process, in which latter method of operation air venting does assume considerable importance in many instances, and indeed is often found to be the practical solution of a number of operating troubles, as will be explained.

In view of the relative infrequency of trapped air and the resultant need for venting of the mould, simple solutions can very often be applied. These cures take the form of cutting shallow channels along contiguous surfaces adjacent to the point of air pocket formation. Such channels should preferably lead the air outside the mould; or an alternative method is one which employs a common loading chamber where the mould is large and of the many-impression kind. The flash surface between each impression is then relieved a slight amount so as to leave only a very narrow flash prevention land at each side of the cavity, rather than a fully sealing land over all surfaces between the cavity edges. Often such a relief of quite a small amount will suffice. It will be a sound plan to commence with a relief amount of not more than .005, after which tests should be made.

Such land relief not only promotes easier escape of air or gas, but also ensures obtaining the thinnest flash, which, of course, means a more accurate and better-finished article.

There is one useful point which might profitably be mentioned before leaving the consideration of compression moulds, which concerns a practice which the writer has met with repeatedly, which may be termed "the indiscriminate location of air vent channels or similar provisions."

Very often when examination of a newly moulded article made from a brand-new mould reveals the presence of blow-holes, or spongy spots, due to trapped air or unescaped accumulations of gas, remedy is hastily sought by providing venting channels without giving adequate thought to their best location.

Unless some care is exercised in this regard, it may be found that the vent

channels direct air streams away from the affected spot only to lead them to more important portions of the moulding, so that the latter condition proves worse than the first.

It is not always the best policy to locate a vent at the remotest point of a cavity, but rather an effort should be made to determine the direction of material flow, and usually it will be found that air pockets develop at the junction of opposed or converging streams, which locations should then be carefully discerned on the mould cavity and as far as practicable air vents provided near them so that the air likely to be trapped between the approaching flows of material will have a better chance to escape.

Maintenance troubles likely to develop due to lack of air vents in compression moulds are very few, and these will centre around the following mould component members. Cavity wall and parting-line surface edges of same; ejector rods and bearing holes in block; cores, either fixed or movable; especially where the portions projected into the cavity are of slender section or great length; other detachable portions of mould.

In connection with all these members some damage may be inflicted on one or another of them as a result of attempts on the part of an operator to remove a sticking imperfectly formed moulding from the cavity or ejector rod. But if reasonable care is taken and insistence made that all such badly or incompletely formed articles shall be removed from the mould by a skilled person, little serious damage will be done.

Venting Technique and Methods in Relation to Injection Moulds

As will be understood by readers in considering injection types of mould and the exigencies imposed by this process, the possibility of trapped air or gas, or retarded elimination of same from the mould cavity becomes of considerable importance, as a result of the very great pressures needed to force the plasticized material into the mould. Pressures up to and beyond 3 tons per sq. in. are employed, and the plastic material is injected at very high speed into the mould.

In this process it is essential that the mould shall be filled completely in the shortest time and with the minimum of injecting pressure or temperature rise of the mould itself.

In order the better to understand the needs and extent of air venting and the troubles likely to accrue from trapped air it will be helpful to attempt some understanding of the technique of venting as applied to injection moulds.

First it must be borne in mind that it is somewhat difficult accurately to describe the exact behaviour of thermoplastic materials when injected under the above conditions into a mould. For instance, it is not clear yet whether they behave as true liquids, or as sluggish viscous partial liquids. Mould designers and engineers, and also maintenance toolmakers should, however, always base their calculations for locking or clamping arrangements, fixture of cores, or mould parts, safety devices, etc., on the assumption that the plastic material will behave as a proper liquid.

Since the material is injected into mould blocks which are maintained in a very cool condition in relation to itself, it will be obvious that the first portions of the incoming plastic stream impinging upon the cavity wall surfaces will tend to be arrested in flow, and chilled at the same time. In actual fact, this chilling will occur almost simultaneously with entry of material into mould.

The tendency will be for the portions of plastic material forced into contact with the cavity wall to become chilled to the point of solidification first, so that one could visualize the moulding at that stage as possessing a more or less thin outer skin which is solid, whilst the internal core portion remains plastic and which will require some little time before finally setting. Probably in most cases this final all-through solidification will only be accomplished some time after the moulding has been ejected from the mould.

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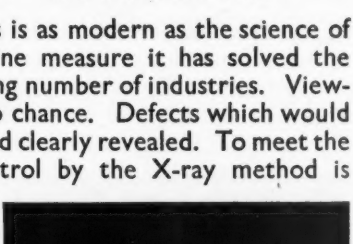

Radiograph of moulded assembly showing incorrect location of metal insert.

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One of the proclivities of this kind of moulding formation is that the creation of a hard outer skin as the first stage towards solidification will tend to seal off all the numerous and tiny crevices between the various mould members, which normally one would expect to serve as means for allowing air or gases to escape. It will be easily seen that in the case of mould cavities of complicated shape involving undercut portions, recesses, deep channels, intricate corings, etc., the possibilities for trapping air become greatly increased.

It is often found that troubles due to trapping of air usually increase or become more pronounced when the mould has been freshly cooled, or allowed to stand inactive for a short period and so permitting its temperature to fall appreciably. Such a drop in mould temperature will tend to hasten skin solidification on the newly injected material, and, of course, somewhat less time for any surrounded air streams or pockets to find normal evacuation unless additional special vents are provided.

It may be urged that with the usual run of injection mould constructions the parting-line surfaces of the respective blocks are never so accurately bedded together to ensure so perfect a matching that the joint is in effect actually air-proof. This is often true and, indeed, where other circumstances permit, the mould engineer can adapt the parting-line surfaces of each block in such a manner as to promote air escape, as will be explained more in detail at a later point.

But it has to be remembered that on injection moulds the parting-line surface is not always in one plane, often it follows an irregular path and very often it is not easy so to arrange for air vent channels, etc., across such surfaces without re-introducing the air into some other equally important portion of the mould.

Then again, it must be realized that the entire solution for trapped air does not consist in drawing it off from a particular point, but also in directing or canalizing such a drawn-off air stream harmlessly so that no interference shall be caused to other parts of the mould.

It is, in fact, not always as fully realized and appreciated as it might be amongst mould engineers and maintenance toolmakers especially, just how important a part proper venting arrangements can play in securing not only improved injection mouldings and better production, but what is equally as essential, freedom from mould troubles, such as damage to component parts, and the need for repeated repairs adjustments, corrections, or alterations.

Venting provisions when intelligently understood and applied to a particular mould construction difficulty may be utilized with good effect by the maintenance engineer, and may rightly be claimed as additional safeguarding measures which in practice will assist in avoiding excessive flash, incomplete mouldings, poor surface finish, loss of strength due to internal malformation, slower output, increased maintenance charges on moulds and so on.

Describing Some Mould Faults Associated With Trapped Air Formations

Where pockets of air are allowed to remain too long within the mould the finished moulded article may not be fully moulded, or its walls may be of such a weakened condition or thinness that difficulties will arise when ejecting the part. For the guidance of readers the author here enumerates a number of these common troubles as being indicative of the kind of mould damage which may arise.

(a) There may be only a partial formation of the moulded article to such an extent as seriously to weaken the finished product, or to lead to loss of weight, wall strength, and generally impaired tensile strength. Also sinkings may occur upon essential surfaces, whilst the finish may be below standard. In the case of intricately cored components misalignment of the finished holes is apt to arise.

(b) Ejection of such partially formed mouldings will usually be accompanied with troubles of the following nature.

Instead of the ends of the ejector pins bearing against a solid surface of sufficient strength and thickness the portion may give way or completely collapse, allowing the ejector pin to cut through the component wall. The moulding will thus tend to hang up on the pins by being thrown awry from its correct ejection path, and generally will require some manipulation to remove.

(c) In extracting such incompletely formed articles the ejector pins themselves may suffer damage, such as by being bent over, or even broken. This, of course, is more likely to occur in cases where the ejectors can only be made of small diameter and have also to pass into the cavity area for a long distance.

(d) In serious cases of jamming of a partially moulded piece, often it will not be possible to eject it at all in the normal manner by means of the pins. Instead, the part may have to be prised out of the cavity, or from the pins. In performing such operations great care will have to be taken to avoid inflicting damage to adjacent parts of the mould, and it will be very easy to raise burrs on the knife edges of the cavity, say, or to damage slender cores, and so on. In actual fact, the writer has experienced damage to mould members on numerous occasions from this cause.

(e) Again, should some of the ejector pins break through the wall of a partially formed component, this will in turn cause an unequal ejection pressure to be set up on the sliding ejector rail. In the absence of very substantial guide pillars, the latter may become distorted due to the out-of-line movement of the rail. Should this occur repeatedly, increased wearing pressure will be imposed upon the guide pillars and the holes in ejector rail, and ensuing operations of this latter member will be characterized by stiffened working, and even eventual seizure.

(f) Similar troubles will be experienced in those designs using stripper sleeves for ejection instead of pins. The sliding sleeves passing along cores to effect the push-off may become jammed as a result of the unequal side pressures set up, or at best suffer from stiffened operation because of additional binding action due to roughening and wearage of sleeve bores and their guide cores.

(g) Subsequent machining or assembling operations may also be adversely affected by trapped pockets of air in the mould leading to partially formed mouldings. This may entail the frequent and costly breakage of twist drills, taps, or other cutting tools used, or that screws, pins, studs, etc., cannot be secured properly in position or correct locations due to spongy patches.

(h) Where the mould has a number of impressions, porosity may also lead to other troubles such as damage to cores, cavity surfaces, gates, and runners caused by efforts to extract a sticking component. Where the component is of small size it often happens that an operator may fail to notice that one moulding has not been ejected, and the next closing movement of the mould blocks will lead to a serious jamming of parts, due to presence of the partially completed moulding.

(i) Trapped air not only leads to incomplete mouldings and injuries to mould members as just described, but may also cause a burning of portions of the moulding as a result of the increased heat generated by the high compression of trapped air. Such a rapid and excessive temperature rise, particularly if localized, may involve stiffened working of the mechanism. Such increased heating will also produce undesirable effects on the mould members as a result of the unequal expansion and shrinkage. Lubricants may be burnt out, leaving essential sliding or rotating mould members bereft of an oil supply.

The above are, of course, only a few of the numerous recurring operating snags likely to arise when an injection mould is not adequately vented. Whilst such troubles are admittedly generally not of a serious nature when taken separately, it usually happens in practice that several of them are to be found associated with any particular venting difficulty, and the correction of the various faulty features thus created demands the frequent atten-

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tions of the maintenance toolmaker, and often the withdrawal of the mould from production for ill-spared lengthy periods.

Considering all these features, therefore, it will be readily appreciated that it is imperative that the toolmaker in charge of efficient upkeep of moulds should be closely familiar with the essential objects of air venting of moulds and the best technique involved, as well as methods of venting to be applied in order to obviate troubles of the kind already mentioned.

To prevent them from developing with cumulative effect it will be necessary to devote due thought to the subject of possible trapping of air and the restriction of exits whilst the mould design is in its early stages and well prior to commencement of actual construction.

Explanation of Air Venting of a Mould

Earlier in this article the possible behaviour of the air contained with the mould cavity when subjected to the pressure of the incoming plastic stream has been considered and effects noted. But it should be remembered that the amount of air within the actual moulds is not the sole consideration confronting the designer and mould engineer in their endeavours to provide effective egress for air and gases.

As is commonly understood the injection process comprises the forcible injection of a plasticized stream of material heated almost to fluid condition into the closed mould blocks at the appropriate time. The mould blocks are brought into intimate contact with the nozzle. The stream of plastic material has to traverse from the pressure cylinder, through the sprue channel, into the mould runners and into the cavity.

Referring to the partial sectioned view illustrated in Fig. 1 this is clearly shown, and it will specially be noted that the volume of air which has to be displaced at each charge shot from the pressure cylinder is equal to the volume of the plastic charge injected into the moulds, and not simply the quantity of air contained within the mould cavity.

When the injection plunger has finished its injection stroke towards the moulds and is drawn back again towards the right hand as shown, during which movement the moulded article is ejected from the blocks, it will draw in a certain amount of air which will be retained within the forward end of the pressure cylinder. Air will also be held within the sprue channel and runners and cavities of the mould.

There will be the minimum amount of air present in the normal injection system, and this also must be expelled in advance of the incoming plastic charge with each injection shot. It is, of course, the designers' duty to arrange satisfactory measures to accomplish the scavenging of this volume of air in such a manner that none becomes trapped or retarded in its outgoing.

Considering again the diagram in Fig. 1 it will be obvious that the volume of air ahead of the plastic charge will be caused to move at great speed and under heavy compression once the injection cycle commences. If the flow of such air has to follow very irregular circuits due to presence of cores, insertion parts, or cavity configurations, for example, there will obviously be danger of trapping

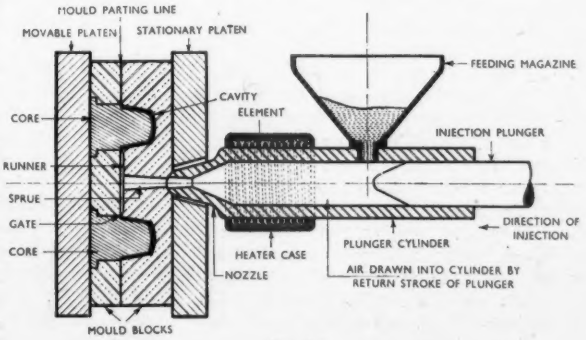

Fig. 1.

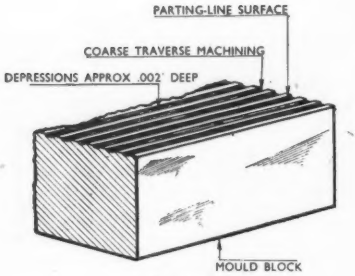

Fig. 2.

portions of same because a considerable proportion of the plastic material will find its way into the cavity and become solidified before all the air has been evacuated.

One important feature to be observed in connection with the foregoing description and illustration at Fig. 1, is that of the need for maintaining all runners, sprue channels, gates, etc., as short and as direct as possible so as to keep down the volume of air.

Methods of Venting

Several useful methods are customarily employed by mould makers for ensuring adequate means of air escape, and the most widely used conventional method is shown at Fig. 2. This is a very serviceable plan, although its uses will mainly lie in connection with moulds of simple design and not having a large number of impressions.

This illustration shows only a portion of one mould block which is sufficient to indicate the nature of the method used and how it is applied. Essentially, it consists of providing means for air to escape over the parting-line surface by so machining the respective surfaces of each block that shallow channels are contained thereon. Instead of machining these surfaces with a highly smooth and unbroken finish, the block is machined up, either in the shaping, milling, or grinding machines, using a very coarse feeding motion so as to form a flat face, but one made up of a regular series of feed depressions as is shown in Fig. 2. These depressions, it will be observed, are spaced regularly apart, thus creating the effect of hill and valley surface.

The maximum depth of the depressions is only very slight, in fact never greater than .003 in. In width such slight depressions may be made anything up to ¼ in. if necessary.

Both blocks are, of course, machined up in this manner, but care should be taken to machine them in such a manner that the line of direction of the depressions does not coincide, in which case the vent channel will be too great and allow ingress of plastic material. Right-angled location of these feed depressions will probably be the best arrangement.

The finished mould blocks after machining in the above manner will then be lapped together to ensure that portions immediately surrounding the cavity edges will be close fitting on the crested portions of the surfaces.

This is extremely simple and permits air to escape in all directions over the parting-line surface, thereby imparting very rapid means for dispersal of undesirable air streams. But it has limitations as follows:—

If the mould cavity is very deep, and narrow, or interposed deep down with cross cores, inserts, or projections, all of which are liable to act as baffles and pockets for the air flow set up during injection, it may often be found that venting via parting-line alone will not be sufficient, and other means will have to be adopted to supplement.

Fig. 3 shows yet another simple and often used method of venting. This illus-

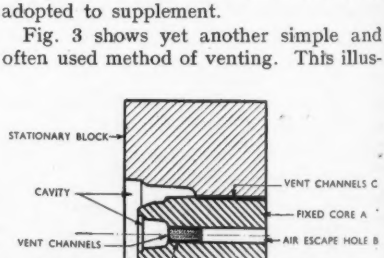

Fig. 3.

tration indicates only the stationary mould block of the set. Into this member is cut a fairly deep cavity, into which recess is interposed the large diametered fixed core member A, which is a force fit within the plain hole in the block, and its end face finished flush with the rear face of the block. The front end of this fixed core normally residing within the cavity is recessed out for a short distance to form a boss projection on the moulding. The cavity it will be seen is edged fed from the runner across the parting-line face.

In operating this type of mould, which by the way had four cavity impressions, one only being here illustrated, however, it was found that air tended to become trapped right down at the bottom end of the cavity, and also at the bottom of the recess in end of fixed core A, and instead of obtaining clear-cut finished mouldings they were characteristized by broken edges and bad surface finish.

To overcome these difficulties the fixed core A had to be vented in the manner here shown. A series of vent channels were filed lengthwise along the plain cylindrical shank of the core housed in the block as shown at C. These channels were first made about .0015 deep, little more than a scratch it will be observed, and located equally spaced around the core, four being provided. Later it became necessary to deepen these channels, making them .0025 deep. These channels were extended right up to the portion of core required to form the shape in the finished moulding.

To ensure proper escape means for the air trapped in the recess in end of core, a small hole B ($\frac{3}{16}$ in. diameter) was drilled centrally up the core and breaking through into cavity recess at end. Fitted tightly into this escape hole B was a special plug D. Here again this latter piece was filed lengthwise on its outside diameter to provide shallow vent channels of approximately the same depth, but narrower in width than those provided on the fixed core A.

By this simple means the air stream created immediately in advance of the incoming stream of plastic material was driven out of the danger spots without trouble.

Whilst such a method is extremely handy, easily effected and inexpensive, features which will appeal strongly to many mould engineers having to provide air vents on moulds, it is only fair to point out several disadvantageous points which are likely to arise in practice, and which, if not realized beforehand, may lead to additional troubles of a worse kind than the trapped air pockets they aim to cure.

Taking first the matter of the small plug piece D within the fixed core A. As will be understood if such a member is of small diameter, the filing of a series of tiny flats along its outer surface will have the effect of diminishing the surface area in contact with the drilled hole in core, thereby directly tending to reduce the frictional grip and tightness of fit of the plug. This means that care will have to be exercised when venting such plug pieces lest too much material is removed leaving the plug too easy a fit within its hole. Should this occur there will be the risk of forcing out the entire plug during injection, an occurrence which, in the case of some mould constructions, may cause irreparable damage.

A second undesirable feature often associated with this form of venting is that, after a while, troubles arise by reason of slight protruberances on the end of the moulding due to tiny particles of material being injected into the ends of the air vents, which have become slightly enlarged at the edge of their entry into cavity because of natural abrasive action of some materials, or other cause.

A third feature to be observed relates to the danger of blocking up such air vents. Actually, the channel along which expelled air has to travel is very narrow, and thus easily prone to blocking by the ingress of dirt during storage of the mould between production runs, or by burnt-up lubricant, or moisture residues, or by tiny particles of solidified plastic material adhering after previous shots.

To avoid this latter trouble will mean that the maintenance engineer will fre-

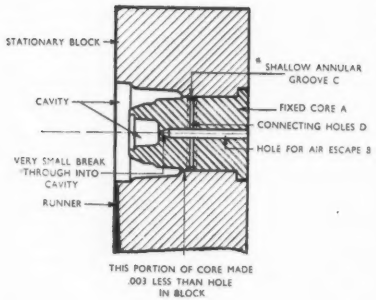
STATIONARY BLOCK
SHALLOW ANNULAR GROOVE C
CAVITY
FIXED CORE A
CONNECTING HOLES D
HOLE FOR AIR ESCAPE B
VERY SMALL BREAK THROUGH INTO CAVITY
RUNNER
THIS PORTION OF CORE MADE .003 LESS THAN HOLE IN BLOCK

Fig. 4.

quently have to inspect the mould and mouldings to detect the prevalence of air pockets, and then to remove the fixed core A to clear the channels afresh.

A much-improved form of air venting the same mould cavity is shown in Fig. 4. Here it will be seen that the fixed core A is provided with a head portion which resides normally within the recess end of the hole in mould block. Drilled up the centre of this core member is a fairly large hole as at B, which, however, is not broken through into the recessed portion at end of core at any rate for its full diameter. Instead, the point of the drill only is permitted to break through the wall into recess as shown. The drill should be specially ground on its cutting edges to an altered angle (about 50 degrees included angle will usually be found sufficient) and the diameter of the drill point allowed to break through should not exceed .007, less if possible. The reason why the cutting end of the drill has to be ground to a different angle is to ensure that there is no weakening of the wall immediately behind the recess, otherwise, with a normal drill angle, there would be a danger of the high injection pressures causing a displacement of the entire wall, and a wrongly shaped moulding would result.

To vent the main mould cavity, the fixed core A is provided with a shallow annular groove shown at C. This is located about $\frac{1}{8}$ in. from the line of core breakage with end face of cavity. It is made about $\frac{1}{8}$ in. wide and up to $\frac{1}{16}$ in. deep. The width and depth do not matter greatly, but the core should not be weakened unduly in the case of small-diametered members.

Drilled diametrically across the fixed core starting in from the bottom of groove C are the two connecting holes D, which it will be seen pass through the centre hole B. Thus, there is afforded a clear channel from the groove C to exterior of the mould block through which air will be free to pass.

The diameter of the very short, plain portion of the fixed core A to the left of annular groove C is reduced slightly as indicated, so as to provide a very small gap for the entry of the air stream during injection. A diameter reduction of not more than .003 will usually suffice, which dimension is too small to allow plastic material to enter.

This is a much-preferred form of venting for the following reasons:—

Each injection shot will tend to clear the way of escape rather than to block it up as in the previously described method in Fig. 3.

Since there is no centre plug housed in the fixed core member A, it will easily be possible for the maintenance toolmaker to insert a finely pointed tool occasionally to open up the small break-through of the air escape hole B, should this ever become blocked. This clearage can be accomplished without removing the fixed core or mould block.

The venting channels can be made of very ample capacity, in contrast to those provided on the core in Fig. 3. The only restriction in size occurs at the points of entry in each case.

There is no risk of reducing the tightness of fit of the core members, and also since no special venting plug is needed as in previous instance there will not be any visible circular marking on the end face of the inner boss of moulded article such as is likely to arise when a plug is used.

Another advantage lies in the fact that this design of air venting enables easy attachment of a suction pipe to the centre hole B in the fixed core when the means of positive exhaust of air is employed.

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This style of air vent is especially suitable for cores, etc., of small diameter because of its simplicity and minimum weakening effect upon the part concerned.

At Fig. 5 two illustrations are shown of methods of venting plug pieces or core pins, such as will usually be employed in deep cavities, similar in layout to those which are indicated in the sectioned view of a mould block assembly in Fig. 6.

As will be observed, the main cavity formation is in the stationary mould block, and extends for a considerable depth, which, coupled with the fact of smallness of diameter, will certainly mean that in production some air lock will cause trouble at the bottom end of these cavities.

To overcome such disabilities, the mould engineer often will bore the cavity clean through to rear face of the mould block, making the hole parallel from normal end face of cavity to rear face of block, and then to insert a stopping-off plug piece of the kind illustrated in Fig. 5.

By adopting this method of construction it will easily be possible for him to make air venting provisions at the seat of the trouble. Many types of such plug pieces can be adopted, but, generally, they will be found to be variants of the two types here shown.

Dealing first with the type A (see Fig. 5), this consists of a plain plug having one end enlarged to form a suitable head, between this head portion and the plain cylindrical shank of the plug is machined a groove all the way round. Running into this groove are four shallow flats filed along the full length of the shank portion of plug as shown. As before, these flats will have to be very small, reducing the diameter by no more than .004.

Air can thus pass along the narrow channel afforded by these grooves when the plug is in position, and a final outlet is provided by the four holes drilled through the head of plug and passing clear into the annular groove. By this means a straight passage outwards is given to any air stream.

This type of plug and venting scheme is, however, not strongly recommended in view of the previously mentioned objections to filed flats and their proclivity for blocking up, or reducing the degree of tightness of fit of the plug.

A much-preferred kind of vent plug is illustrated at B in Fig. 5, which has the advantages of being easier and cheaper to produce and is less liable to block up during operation.

Here, again, the plug piece is provided with a headed portion for positive endwise location in the mould block. Near the left-hand end of the plain cylindrical shank is machined a reasonably deep and wide annular groove, as shown. The remaining portion of the shank to the left of this groove should be approximately $\frac{1}{8}$ in., and this end is then reduced slightly in diameter so that it is about .003 less than diameter of hole into which the plug is to be fitted.

A second annular groove is also provided immediately behind the head, and the two grooves then connected up by a machined channel running lengthwise between them. A single outlet hole is then provided in the head of plug so as to pass into the first groove.

In practice such a type of plug will be found more satisfactory, because there is the minimum of restriction to air outlet. If desired, the small hole in head portion could be eliminated and a deep saw-cut made through head down to bottom of the annular groove. If space per-

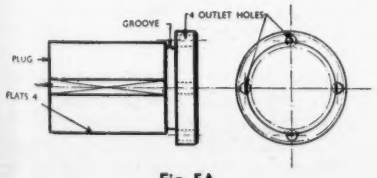

Fig. 5A.

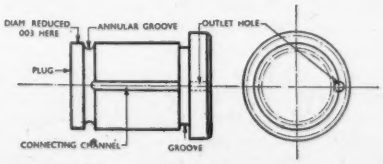

Fig. 5B.

mitted it would be possible to illustrate a number of slightly different types, but essentially their object would be the same as that of the type shown at B, i.e., to ensure the minimum restriction of air passage once the point of entry into plug channels has been made.

Fig. 6 illustrates yet another method of venting, which will often be found extremely useful in the case of deep and small-diametered cavities of the kind shown. This mould is for producing a deep, hollow article or sleeve, and is moulded with the main cavity formed in the stationary block, and fixed cores attached to the movable block, whilst ejection is secured by means of rods passing through holes provided up centre of the fixed cores as shown.

Means for allowing accumulated pockets of air to escape are secured by adapting the ends of the ejector rods in a similar manner to that suggested in respect of the plug described at B in Fig. 5. This, it will be recalled, consists of making a shallow annular groove around the end of rod, leaving a very short portion of rod full diameter to the right of groove. The remaining portion of rod to the left-hand side of this groove is slightly reduced in diameter, as shown in exaggerated form. The normal working clearance needed for free sliding action of the ejector rod within the fixed core will usually be sufficient to allow escaping air to pass. Once the air stream gets past the narrow full-diametered end of rod and into and beyond the annular groove it will have an entirely unrestricted passage outwards.

This, of course, is an extremely simple presentation of how venting of such a deep cavity may be secured, and recourse to this method obviates the need for extending the cavity clean through the mould block and fixing a stop-off plug vented and arranged in the manner described in Fig. 5.

One of the chief advantages ensured by these simple methods is that it permits the mould engineer to provide air escape means at the precise point required. Upon consideration it will be obvious that not much gain would be obtained if the

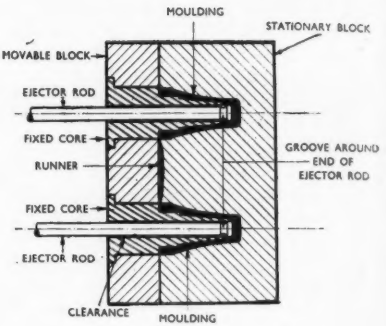

Fig. 6.

parting-line surface of the blocks only were to be vented, as the incoming plastic stream from the central runner would largely serve to obstruct any air tending to pass out of the cavity area towards the movable block.

In cases where a finished moulding has to be ejected by means of stripper sleeves, it will also often be possible to arrange for the ends of such sleeves to be treated in similar fashion in order the better to promote air elimination.

Another method of venting of moulds sometimes employed with excellent results concerns the manufacture of mouldings of such a large size or intricate shape as to cause the injected plastic stream to be split up into a number of separate streams tending to converge upon one point within the cavity area. Usually mouldings of this kind entail relatively long travel for such plastic streams, which thus become subject to considerable cooling, with retarded flow and an appreciable drop in pressure. These factors mean there will be less force available for ejecting air pockets. In addition, at the junction of the various streams of flow a poor weld will usually result unless means is provided for drawing off the accumulated air.

This can be done quite easily in many mould constructions, by the simple expedient of providing an additional dummy cavity adjacent but external to the proper cavities, and to connect these latter to the dummy one by a very shallow runner,

which should be too small to admit entrance of plastic material, but yet sufficient to enable air to pass.

In really difficult cases it may be necessary to go a step further and make the connecting runner large enough to take a thin stream of plastic material as well as air, and the dummy cavity arrangement would then serve to draw off from the main mould cavity the leading portion of the plastic stream, which will be the coolest and least likely to weld effectively. Furthermore, such a dummy cavity if adapted to receive a supply of plastic will set up a certain degree to turbulence at those points where plastic flow converges, thereby promoting improved weld, and better strength feature at that point.

The dummy cavity, of course, will be made any convenient uniform shape, and is not finished off with high polish, etc., as is required for the cavities proper. When the moulding has been ejected the dummy portion will be dressed off in exactly the same way as ordinary runners and gates are trimmed.

In the case of multiple impressions moulds, each of which is of somewhat intricate formation, it may be necessary to provide more than one dummy cavity or well, and in this connection very careful judgment will have to be displayed in selecting the best locations for these air-venting wells, lest the presence of one whilst curing air-locking troubles in respect of certain cavities tends to worsen such conditions in regard to others.

Determining the Location of Air-vent Channels, etc.

A concluding word is necessary concerning the matter of the location of air-venting channels and the like.

Generally they should not be provided indiscriminately around the mouth of a mould cavity and across the parting-line surfaces of the blocks, etc., as often their best location requires a good deal of elucidation and test. In all cases of air trapping troubles, before applying any remedies it is always advisable to determine and study the line of flow taken by the plastic stream, and to provide vents as near as possible to the meeting points of converging or opposed streams in preference.

It is usual practice for the mould engineer to situate a vent at the farthest point of mould cavity removed from the gate. The idea behind this practice being to allow a means of escape to air which will apparently be driven to bottom or end of cavity by the incoming material. It is seriously open to question whether such an assumption is always accurate, because it is highly probable that under normal working such conditions rarely occur. Thus a mould cavity of complex pattern, or provided with baffles in the form of intersecting cores, etc., will drastically alter the direction of flow of the injected material, so that air may be locked at other points than expected.

In fact, in this regard many mould engineers will have observed that in connection with improperly formed mouldings due to air lock, or its too slow escape, there is nearly always a tiny flash of plastic material present in the vents, especially if the mould is old, and particularly when the vents are situated at the remote points of a cavity in respect to the gate, even though the finished moulding may be so impoverished by lack of feed as to consist of a shell only.

This well-known feature is, perhaps, explainable by the fact that the moving plunger or ram within the pressure cylinder sets up a very rapid and powerful displacement of air, forcing it and the material behind with high velocity into the sprue, runner and cavity. The portion of plastic stream first reaching the air-vent channels at end of the cavity is partially forced therein by reason of the build-up of pressure behind possessed by succeeding layers or streams of plastic material.

Complete understanding of the behaviour of plastic material when forcibly injected into the enclosed mould cavity is still far from being secured, and until the time does come when moulders can ascertain with greater certainty the flowing characteristics, it will be neces-

sary to adopt cut-and-dry methods to a large extent in the determination of air-vent location.

Careful examination of ill-formed mouldings should be made as a preliminary step, and it will often be necessary to cut such articles into sections by hand-saw in order the better to discover the exact location of spongy or air-blown portions.

Such action will often be very revealing of the conditions prevailing in the mould cavity, and afford good guidance as to the best place in which the air-vent channels, etc., have to be situated.

Finally, it will be specially necessary for the maintenance engineer to provide a proper set of equipment for use on occasions where a partially formed moulding has to be manually extracted from the cavity. On no account should unskilled machine operators be allowed to perform such tasks, and unsuitably shaped metallic tools or pry bars should on no account be employed.

Very considerate manipulation by brass or copper rods and hide mallet will be required, so as to avoid causing damage to adjacent parts of the mould mechanism by accidentally striking, or using them as leverage points to prise out the offending moulded article.

In cases where the mould is of the multiple-impression type having ejector-pin method of removing finished parts, in the matter of a serious hang-up or jamming of a partial moulding, it will always be the best policy to remove the mould from machine, and to strip the ejector mechanism, in any case, to ascertain where distortion, bending, or even tiny surface fractures have been caused to the pins. Generally, too, ejector pins will need adjustment and resetting, even though no visible bending has taken place.

To obviate serious mould damage, then, due to the foregoing causes, it is essential that the maintenance toolmaker keep close oversight over the working behaviour of the moulds, and in his regular inspections of production and running made during each day, as described in the earlier sections of this series, he will have to devote some attention to this aspect of mould use. Operators of machines will also require some training and instruction on the proper steps they should take when improperly formed moulding begins to develop, and made to appreciate that the removing of sticking parts and readjustment of moulds, etc., is a specialist's job. In a later section, which will deal specifically with tools, fixtures and appliances for use of the maintenance mould engineer, some more detailed mention will be made of small hand tools designed to be specially applicable for facilitating the foregoing operations.

Succeeding section 13 will examine mould constructions, incorporating insert-locating, retaining, and loading or unloading provisions, in order to see how such useful mechanisms may be adapted or arranged to ensure the minimum of maintenance or upkeep service, and at the same time ensure the maximum of production results.

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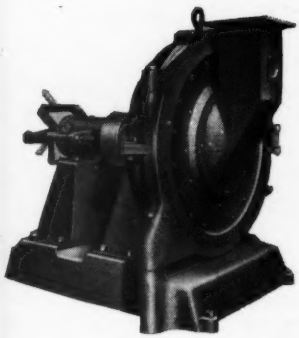

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Resinoids and Other Plastics as Film Formers

By B. J. BRAJNIKOFF,
Consulting Electrical Engineer

XXV.—Synthetic Coatings Based on Acetylene (Contd.)

BEFORE we discuss the principal work originated by the Favorsky's school in Russia, it is important to present a brief account of the successes achieved during the past few years by American chemists in the field of vinylacetylene and its derivatives.

The Derivatives of Vinylacetylene

Vinylacetylene was first obtained by Willstatter and Wirth[395] in 1913 by distilling in vacuo the diquanternary ammonium base derived from 1.4 tetramethyldiaminobutene. For this reaction the aforesaid nitrogeneous base is broken up according to the following scheme:—

(I) $(CH_3)_3\overset{OH}{\overset{|}{N}}-CH_2CH=CHCH_2-\overset{OH}{\overset{|}{N}}(CH_3)_3 \longrightarrow$

$$CH_2=CH-C\equiv CH + 2N(CH_3)_3 + 2H_2O.$$

The chemistry of vinylacetylene only began to grow vigorously decades later, after Nieuwland, Carothers and their collaborators[396] had discovered a simple and readily available method for its production by means of the catalytic polymerization of acetylene under the action of copper and ammonium chloride:—

(II) $2CH\equiv CH \longrightarrow CH_2=CH-C\equiv CH.$

Since the discovery of this reaction there has been produced a great number of vinylacetylene derivatives, among which there are compounds of extremely important industrial value.

In the first place, advantage has been taken of the highly unsaturated nature of vinylacetylene by utilizing it in diverse addition reactions. Of the latter it is specially worth mentioning the addition of hydrogen halides, in particular of hydrogen chloride, occurring in the absence of copper semi-chloride, as was shown by Carothers[397] and his associates in the following manner:—

(III) $CH_2=CH-C\equiv CH + HX \longrightarrow$

$$XCH_2-CH=C=CH_2$$

where X = chlorine, iodine or bromine.

These allene haloid derivatives, under the influence of various catalytic agents, easily undergo an irreversible isomerization with the formation of the so-called haloidprenes. This isomerization occurs particularly readily under the action of cuprous chloride in presence of hydrogen halide acids; its iodine derivative isomerizes on merely heating to 125 degrees to 130 degrees C.

As is known, the addition of hydrogen chloride to vinylacetylene opens up the way for producing a new chloroprene rubber.[397] As demonstrated by Dykstra,[398] in a manner analogous to hydrogen halides, haloid-ethers can also be added to vinylacetylene.

The last-mentioned product, like chloroprene, polymerizes into a rubber-like substance. The addition of hydrogen chloride, which was very thoroughly studied in the case of vinylacetylene, has been examined by Carothers and his

(IV) $$XCH_2-CH=C=CH_2 \xrightarrow[HX]{Cu_2X_2} CH_2=CH-CX=CH_2.$$

(V) $$CH_2=CH-C\equiv CH + CH_3OCH_2Cl \xrightarrow{BiCl_3} ClCH_2-CH=C=CHCH_2OCH_3;$$

(VI) $$ClCH_2-CH=C=CHCH_2OCH_3 \xrightarrow[HCl_2]{Cu_2Cl_2} CH_2=CH-CCl=CHCH_2OCH_3.$$

(VII) $$CH_2 = CH - C \equiv CH \xrightarrow[\text{Liquid } NH_3]{Na\,NH_2} CH_2 = CH - C \equiv CNa,$$

$$CH_2 - CH - C \equiv CNa + RX \longrightarrow CH_2 = CH - C \equiv C - R + NaX;$$

(VIII) $$CH \equiv CH + RCH_2 - CO - R \xrightarrow{NaNH^2} CH \equiv C - \underset{\underset{OH}{|}}{\overset{\overset{R}{|}}{C}} - CH_2R,$$

$$CH \equiv C - \underset{\underset{OH}{|}}{\overset{\overset{R}{|}}{C}} - CH_2R \xrightarrow{-H_2O} CH \equiv C - \overset{\overset{R}{|}}{C} = CHR.$$

co-workers[399] also in application to the various homologues of vinylacetylene.

The latter compounds have been obtained in the manner shown above.

The addition of hydrogen chloride to these vinylacetylene homologues in presence of cuprous chloride proceeds in each case in the same fashion as when it is applied to vinylacetylene itself, i.e., as the final products easily polymerizable homologues of chloroprene are obtained.

The speed of polymerization and the character of polymers of these products depend to a great extent upon their structure. Thus, for example, chloroprene and bromoprene polymerize 700 times more rapidly than isoprene. However, this accelerating influence on the polymerization is observable only in the event of a halogen replacing hydrogen of butadiene in the β- position. On the contrary, every substitution for hydrogen of the diene in the α- position decreases the velocity of the polymerization. Therefore all the aforesaid homologues of chloroprene possessing the structures:

$$CH_2 = CH - CCl = CHR; \text{ and}$$
$$CH_2 = CCl - C(R) = CHR,$$

polymerize slower than chloroprene itself.

The foregoing regularity is maintained even in the case where the substituting agent in α- position is a halogen.

Among other addition reactions of vinylacetylene should be mentioned the addition of alcohols and organic acids. Nieuwland and his collaborators[400] have revealed that mono-and-di-substituted acetylenes easily add, under the influence of boron trifluoride and mercury oxide, two molecules of alcohol with the formation of ketals:—

(IX) $$R - C \equiv C - R + 2R'OH \longrightarrow RCH_2 - C(OR')_2 - R,$$

where R is hydrogen or an alkyl group.

In this case it has been found that in the presence of BF_3 and HgO there can be added only one methanal, and in order to effect the addition reaction for primary normal alcohols it is necessary to incorporate with the catalyst a small amount of trichloracetic acid. In these conditions glycols and oxycarbonic acids may be added to acetylenes.[401] The striking feature in this connection is the fact that this reaction is confined to the addition of primary alcohols of normal constitution. None of the primary alcohols of iso-structure, as well as the secondary or ternary alcohols, is capable of effecting this combination.

Nieuwland and Killian[402] have demonstrated that vinylacetylene easily adds three molecules of methanal with the formation of the respective trimethoxybutane:—

(X) $$CH_2 = CH - C \equiv CH + 3CH_3OH \xrightarrow[HgO]{BF_3} CH_3OCH_2CH_2C(OCH_3)_2\,CH_3.$$

However, according to investigations of Carothers and his co-workers,[403] in presence of sodium alcoholates and on heating up to 105 degrees C., the vinylacetylene adds only a single molecule of alcohol conforming to the following scheme:—

(XI) $$CH_2 = CH - C \equiv CH + ROH \longrightarrow [ROCH_2CH = CH_2] \longrightarrow ROCH_2C \equiv CCH_3.$$

It is assumed here that the addition of the elements of alcohol to vinylacetylene proceeds in the position 1:4, with the formation of an intermediate allene compound, incapable of being isolated (the bracketed expression), which after undergoing an isomerization yields alkoxydimethylacetylenes.

Addition Reactions with Organic Acids

As was shown by Werntz,[404] the addition of organic acids to vinylacetylene proceeds in the same way as in the case of acetylene and its mono-substituted derivatives. As is known, the addition of carbonic acids to acetylene yields vinyl ethers, and by reacting these acids with alkylacetylenes[405] the respective alkenyl ethers are obtained:—

$$\text{(XII)}\quad R-C\equiv CH + R'COOH \xrightarrow[HgO]{BF_3} CH_2 = \overset{R}{\overset{|}{C}}OCOR'.$$

Werntz, who examined the addition to vinylacetylene of formic, acetic, chloracetic and oleic acids, has found that in these reactions there formed the ethers of butadienol-2 or 2-acioxydivinyls, which are rapidly polymerizable into rubber-like plastics:—

$$\text{(XIII)}\quad CH_2=CH-C\equiv CH + RCOOH \longrightarrow CH_2 = CH - \overset{OOCOR}{\overset{|}{C}} = CH_2$$

However, the foregoing type of reaction did not proceed very smoothly, and the yields were not very large. Dykstra[406] succeeded in the synthesis of the simple ethers of butadienol-2 or 2-alkoxydivinyls by the following series of transformations:—

By analogy with chloroprene, Dykstra has termed these products the oxyprenes. They are colourless, mobile liquids, characterized by the ethereal odour, polymerize much slower than chloroprene itself, and give rubber-like or hard plastic materials, depending on the conditions of polymerization.

Of other vinylacetylene reactions, the most notable are the reactions of substitution and condensation.

Under the action of sodium amide or Grignard reagent on vinylacetylene, there are easily formed sodium- or magnesiumhaloid-vinylacetylenes,[407] by the treatment of which with the aid of the carbonic acid, there may be produced polymerizable vinylpropyol acid.

The interaction of vinylacetylene with K_2HgI in alcoholic solution or mercury acetate in the solution of acetic acid, gives rise to the formation of the mercury derivatives of vinylacetylene characterized by the following constitution[408]:—

$$(CH_2 = CH - C\equiv C)_2\,Hg.$$

By reacting the latter with halogens there can be produced α-haloidovinylacetylenes:—

$$\text{(XVIII)}\quad (CH_2 = CH - C\equiv C) - Hg \xrightarrow{Cl_2\,(Br_2,\ I_2)} CH_2 = CH - C\equiv Cl.\ (Br,\ I).$$

The α-iodovinylacetylene was also obtained and studied by Nieuwland.[409] This is derived with theoretical yield by the action of iodine in liquid ammonia on vinylacetylene:—

$$\text{(XIX)}\quad CH_2 = CH - C\equiv CH + I \longrightarrow CH_2 = CH - C\equiv Cl.$$

All α-haloidovinylacetylenes are very unstable, are inflammable or explode in the air, and, on standing, spontaneously polymerize into a hard brittle mass,

$$\text{(XIV)}\quad CH_2 = CH - C\equiv CH + H_2O \longrightarrow CH_2 = CH - CO - CH_3;$$

$$\text{(XV)}\quad CH_2 = CH - CO - CH_3 + ROH \longrightarrow ROCH_2 - CH_2 - CO - CH_3;$$

$$\text{(XVI)}\quad ROCH_2 - CH_2 - CO - CH_3 + HC(OR)_3 \longrightarrow ROCH_2CH_2C(OR)_2\,CH_3;$$

$$\text{(XVII)}\quad ROCH_2CH_2C(OR)_2CH_3 \xrightarrow[(120^\circ - 140^\circ C.)]{KHSO_4} CH_2 = CH - C(OH) = CH_2 + 2ROH.$$

which is also explosive on impact and heating.[410]

Coffman,[411] who has investigated the condensation of vinylacetylene with the formaldehyde and secondary amines, was able to show that this condensation process progresses just as smoothly as in the case of other mono-substituted acetylenes, examined by Mannick and Chang[412]:—

$$CH_2 = CH - C \equiv CH + HCOH + HNR_2 \longrightarrow$$
$$\text{(XX.)} \quad CH = CH - C \equiv C - CH_2 - NR_2.$$

Through the addition of hydrogen chloride to these amines, a product analogous to chloroprene has been obtained:—

$$\text{(XXI.)} \quad CH_2 = CH - C \equiv CH_2\,NR_2 \longrightarrow$$
$$CH_2 = CH - CCl = CH - CH_2\,NR_2.$$

However, the rate of their polymerization is very slow, and they do not yield any rubber-like plastics.

As has been found by Carothers and Jacobson,[413] during the condensation of vinylacetylene with ketones, under the influence of molecular quantities of sodamide, there are easily obtained the ternary vinylethynylcarbinols:—

$$CH_2 = CH - C \equiv CH + R - CO - R \longrightarrow$$
$$\text{(XXII.)} \quad CH_2 = CH - C \equiv C - \underset{\displaystyle R}{\overset{\displaystyle R}{\overset{|}{\underset{|}{C}}}} - OH.$$

These alcohols, which are colourless, mobile liquids, are also capable of the spontaneous polymerization into a hard, glasslike body.

Finally, there have been investigated certain interchange reactions of vinylacetylene. Thus, for example, the sodium-vinylacetylene very vigorously reacts with alkylhaloids, and, provided that the reaction is conducted in the medium of liquid ammonia, there are derived high yields of the respective alkylvinylacetylenes, already mentioned before.[414] These alkylvinylacetylenes, on standing for two to three months, polymerize, giving a viscous syrup of yellow colour.

There were also studied the following reactions of the 4-chlor-1.2-butadiene, which is formed through the addition of hydrogen chloride to vinylacetylene.

According to Coffman,[415] the course of the action is:—

$$CH_2 = C = CH - CH_2Cl + NaCN \longrightarrow$$
$$\text{(XXIII.)} \quad CH_2 = CH - CH = CHCN;$$

$$\text{(XXIV.)} \quad CH_2 = C = CH - CH_2Cl + RMgX$$
$$\longrightarrow \begin{cases} \longrightarrow CH_2 = C = CH - CH_2R & \text{(i)} \\ \longrightarrow CH = C(R) - CH = CH_2 & \text{(ii)}, \end{cases}$$

where a radical R stands for CH_3, C_2H_5, C_4H_9, C_7H_{12}, and, according to Carothers and Berchet,[416] the radical $R = C_6H_5CH_2$.

The nitrile of β-vinylacrylic acid is the only product of the first interchange reaction, and its structure has been proved by the reduction to normal amylamine, as well as by means of saponifying β-vinylacrylic acid into ethyl ether. This substance polymerizes with a speed 20 times greater than that of isoprene and gives a plastic material possessing rubberlike properties.

Thus, the most characteristic and valuable feature of nearly all the derivatives of vinylacetylene is there pronounced ability for the polymerization. This polymerization is conditioned either by the presence in the molecule of these compounds of the conjugated two double bonds, or by the presence of the conjugated system of the double and triple bond, and the character of the resultant polymer varies within wide limits, depending on the composition and the structure of the initial monomer and conditions of the polymerization process.

On account of their ability for the polymerization and the diverse chemical transformations, the derivatives of vinylacetylene, side by side with a considerable theoretical significance, also acquire great practical importance. By virtue of the fact that vinylacetylene derivatives possess a relatively simple constitution and their structure can, in most cases, be easily and exactly determined, they

represent a very convenient range of materials for the studying of a highly important theoretical problem—namely, the connection between the structure of an organic molecule and its capacity for polymerization and the formation of polymers of one or another character and property.

This, evidently, calls for the necessity of an extensive and systematic exploration in the chemistry of vinylacetylene transformations, and emphasizes the exceptional and timely interest of this research for the technology of the film-forming and kindred compositions, not mentioning the plastics industry generally.

(To be continued)

REFERENCES

(395) *Willstatter and Wirth; Berichte*, 46, 535, 1913. **(396)** *Nieuwland, Carothers and Associates; J. Amer. Chem. Soc.*, 53, 4,197, 1931. **(397)** *Carothers and Co-Workers; J. Amer. Chem. Soc.*, 54, 4,066, 1932; 55, 786, 1933; 55, 2,807, 1933. **(398)** *Dykstra; J. Amer. Chem. Soc.*, 58, 1,747, 1936. **(399)** *Carothers and Collaborators; J. Amer. Chem. Soc.*; 55, 1,662, 1933; *ibid.*, 54, 4,070, 1932. **(400)** *Nieuwland and Co-Workers; J. Amer. Chem. Soc.*, 56, 1,130, 1,384, 1934; *ibid.*, 57, 2,006, 1935; *ibid.*, 58, 80, 892, 1936; *ibid.*, 58, 892, 1936. **(401)** *Killian, Hennion and Nieuwland; J. Amer. Chem. Soc.*, 58, 1,658, 1936. **(402)** *Nieuwland and Killian; ibid.*, 56, 1,786, 1934. **(403)** *Carothers, Jacobson and Dykstra; J. Amer. Chem. Soc.*, 56, 1,169, 1934. **(404)** *Werntz; ibid.*, 57, 204, 1935. **(405)** *Nieuwland and Hennion; ibid.*, 56, 1,802, 1934. **(406)** *Dykstra; ibid.*, 57, 2,255, 1935. **(407)** *Carothers and Associates; ibid.*, 55, 1,094, 1933. **(408)** *Carothers, Jacobson and Berchet; J. Amer. Chem. Soc.*, 55, 4,665, 1933. **(409)** *Nieuwland; ibid.*, 55, 2,150, 1933; *ibid.*, 55, 741, 1933. **(410)** *Carothers and Jacobson; J. Amer. Chem. Soc.*, 55, 4,667, 1933. **(411)** *Coffman; ibid.*, 57, 1,978, 1935. **(412)** *Mannick and Chang; Berichte*, 66, 418, 1933. **(413)** *Carothers and Jacobson; J. Amer. Chem. Soc.*, 55, 1,097, 1933. **(414)** *Jacobson and Carothers; ibid.*, 55, 1,622, 1933. **(415)** *Coffman; J. Amer. Chem. Soc.*, 57, 1,981, 1935. **(416)** *Carothers and Berchet; J. Amer. Chem. Soc.*, 55, 2,807, 1933.

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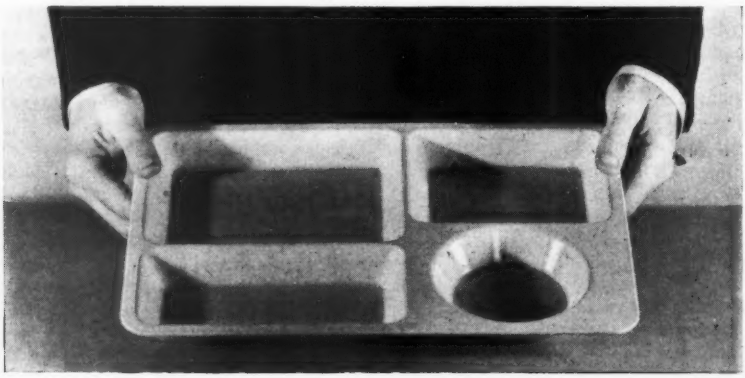

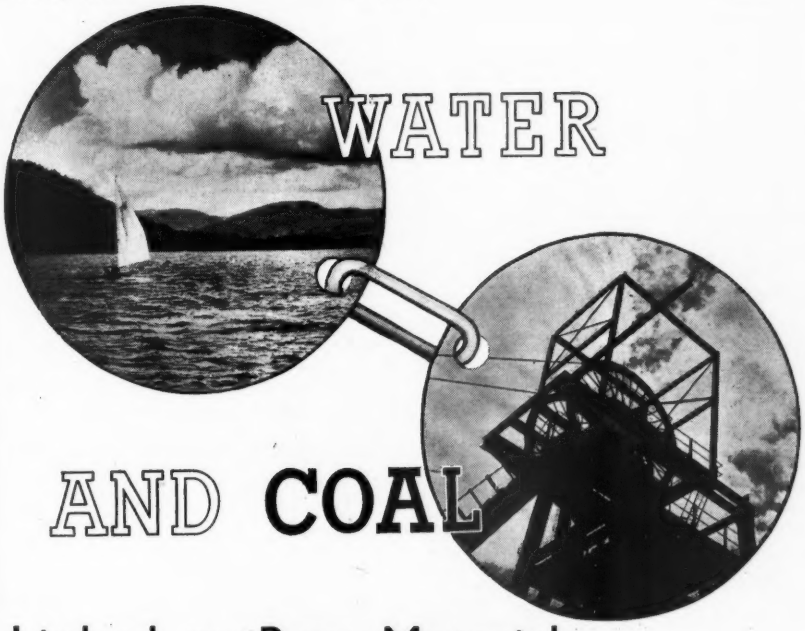

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